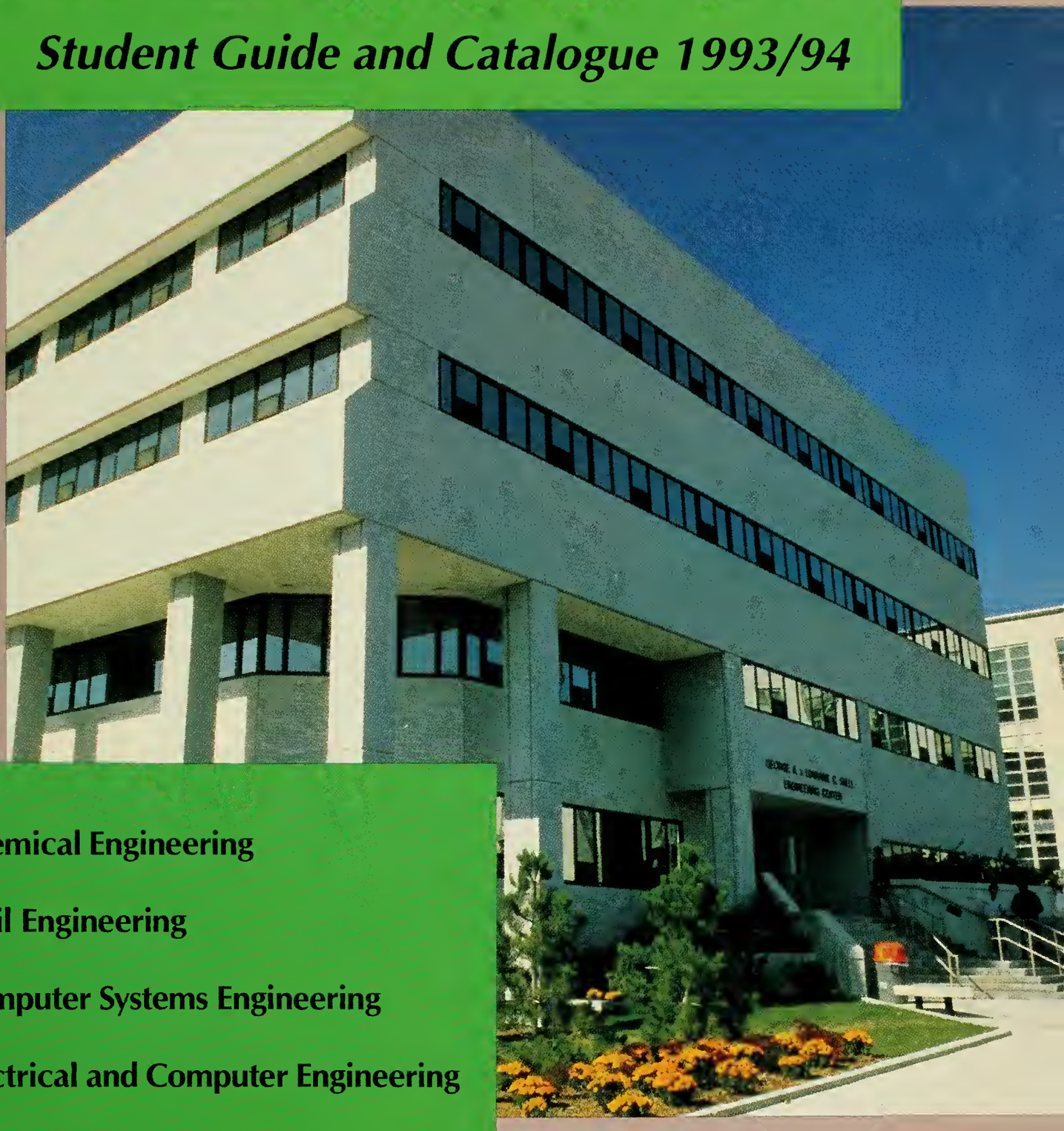
GRADUATE SCHOOL OF ENGINEERING

Student Guide and Catalogue 1993/94



Chemical Engineering

Civil Engineering

Computer Systems Engineering

Electrical and Computer Engineering

Industrial Engineering and Information Systems

Mechanical Engineering

Northeastern University
Boston, Massachusetts

Graduate School of Engineering

Northeastern University

Boston, Massachusetts

Dear Graduate Student:

This Student Guide and Catalog is developed for your convenience in program planning.

The Graduate School of Engineering has offices in room 130 Snell Engineering Center. During the fall, winter and spring quarters it is staffed from 8:30 AM to 4:30 PM, Monday through Friday. We are open in the evenings during the academic year from 5:00 PM to 8:00PM on Mondays in Boston and in Burlington from 5:00 PM to 8:00 PM on Thursdays. During the summer we are staffed from 8:00 AM to 5:30 PM, Monday through Thursday. Administrative matters should be referred to us. The staff consists of:

Dr. Yaman Yener,	Associate Dean of Engineering for Research and Graduate Studies
Stephen L. Gibson,	Assistant Director
Jennifer A. Black,	Administrative Assistant
Hattie M. Williams,	Staff Assistant

You may reach this office by calling (617) 373-2711.

Dr. Yaman Yener
Associate Dean of Engineering
for Research and Graduate Studies

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THE UNIVERSITY

PRESIDENT'S MESSAGE

Northeastern University, located in the heart of Boston, is an exciting, vibrant place to pursue graduate studies. I am proud and delighted to introduce the University to you.

Northeastern offers students a full complement of graduate programs in an environment oriented to both scholarship and practical skills. Under the guidance of a distinguished faculty of scholars and researchers, the University's graduate and professional schools have designed each program to meet the academic and career needs of its students. The programs are also tailored to be responsive to the professional climate of the 1990s and are widely recognized to be on the leading edge of technological and theoretical developments in their respective fields.

Each year I have the pleasure of welcoming eager graduate scholars from around the nation and the world to the University. I look forward to greeting you should you decide that Northeastern University's programs suit your academic and career aspirations.

John A. Curry
President

GRADUATE DEGREES

COLLEGE OF ARTS AND SCIENCES

Doctor of Philosophy

- Biology
- Chemistry
- Economics
- English
- Law, Policy and Society
- Mathematics
- Physics
- Psychology
- Sociology

Master of Arts

- Applied Behavioral Analysis
- Economics
- English
- History
- Journalism
- Political Science
- Psychology
- Social Anthropology
- Sociology
- Writing

Master of Education

- Curriculum and Instruction
- Educational Research
- Human Development
- Consulting Teacher of Reading

Master of Science

- Biology
- Chemistry
- Economic Policy and Planning
- Law, Policy & Society
- Mathematics
- Physics

Master of Science in Health Science

Master of Public Administration

Master of Journalism

- News Media Management

Master of Technical and Professional Writing

Certificate of Advanced Graduate Study

- Advanced Literary Study

BOUVE COLLEGE OF PHARMACY & HEALTH SCIENCES

Doctor of Philosophy

- Biomedical Science
- Medical Laboratory Science
- Medicinal Chemistry
- Pharmaceutics
- Pharmacology
- Toxicology

Doctor of Pharmacy

Doctor of Education

- Counseling Psychology
- School Psychology

Master of Education

- Moderate Special Needs
- School Adjustment Counseling
- Severe Special Needs

Master of Science

- Audiology
- Biomedical Science
- Clinical Exercise Physiology
- Hospital Pharmacy
- Human Resource Counseling
- Medical Laboratory Science
- Medicinal Chemistry
- Pharmacology
- Recreation, Sport, and Fitness Management
- Rehabilitation Counseling
- Speech-Language Pathology

Master of Science in Counseling Psychology

Master of Health Professions

- Health Policy
- Physician Assistant
- Regulatory Toxicology

COLLEGE OF BUSINESS ADMINISTRATION

Master of Business Administration
- Executive
- High Technology

Master of Science/Master of Business Administration

Master of Science in Taxation

Master of Science in Professional Accounting

COLLEGE OF COMPUTER SCIENCE

Doctor of Philosophy

Master of Science in Computer Science

COLLEGE OF CRIMINAL JUSTICE

Master of Science in Criminal Justice

COLLEGE OF ENGINEERING

Doctor of Philosophy
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Industrial Engineering and Information Systems
- Interdisciplinary
- Mechanical Engineering

Electrical Engineer Degree

Industrial Engineer Degree

Mechanical Engineer Degree

Master of Science

Master of Science in Chemical Engineering

Master of Science in Civil Engineering
- Construction Engineering
- Geotechnical Engineering
- Public Works Engineering Management
- Structures and Materials
- Transportation Engineering
- Environmental Engineering

Master of Science in Computer Systems Engineering
- CAD/CAM
- Engineering Software Design
- Robotics

Master of Science in Electrical Engineering
- Communications and Signal Processing
- Computer Engineering
- Control Systems and Signal Processing
- Electromagnetics, Plasma and Optics
- Electronic Circuits and Semiconductor Devices
- Power Systems

Master of Science in Engineering Management
- Computer and Information Systems
- General Program
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Industrial Engineering
- Computer and Information Systems
- General Program
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Information Systems

Master of Science in Mechanical Engineering
- Materials Science and Engineering
- Mechanics and Design
- Thermofluid Engineering

SCHOOL OF LAW
- Juris Doctor

COLLEGE OF NURSING

Master of Science
- Nursing Administration
- Community Health Nursing
- Critical Care Nursing
- Nurse Anesthesia
- Primary Care Nursing
- Psychiatric-Mental Health Nursing

ABOUT NORTHEASTERN UNIVERSITY

Located at the center of Boston's thriving educational and cultural life, Northeastern University is dedicated to excellence in research and scholarship and is committed to responding to the educational needs of individuals and the community. Since its beginning Northeastern has pioneered a wide range of educational programs and services for students of all ages.

Northeastern University's roots lie in the Evening Institute for Young Men founded in Boston in 1898. Classes in law were offered at a reasonable cost during the evening for those who worked during the day. The first evening law school in Boston quickly expanded to include other disciplines and added an innovative daytime program which alternated classroom study with work experience. By the time Northeastern was incorporated as a university in 1922, the school had committed itself to "cooperative education by day, adult education in the evening."

Almost a century after its founding, Northeastern is a comprehensive university with eight undergraduate colleges, eight graduate and professional schools, five suburban campuses, and an extensive research division. A private nonsectarian institution of higher learning chartered and authorized to grant degrees by the Commonwealth of Massachusetts, the University is governed by a Board of Trustees elected by and from the Northeastern University Corporation, which is composed of approximately 200 distinguished academic and professional leaders from around the country.

Northeastern University has developed a reputation as a world leader in cooperative education. The Cooperative Plan of Education, initiated by the College of Engineering in 1909 and subsequently adopted by the other colleges of the University, enables students to alternate periods of paid professional work and study. This educational method offers students an opportunity to gain valuable practical experience as an integral part of their education. Begun at the full-time undergraduate level, the cooperative education philosophy has been extended to the graduate level in engineering, business administration, law, professional accounting, and criminal justice.

The University's eight graduate and professional schools including Arts and Sciences, Bouvé College of Pharmacy and Health Sciences, Business Administration, Computer Science, Criminal Justice, Engineering, School of Law, Nursing offer progams leading to Master's and Doctor's degrees in a wide array of liberal arts and professional courses of study. In the field of adult education, the University offers full- and part-time graduate degree programs that are specifically designed to meet the needs and interests of adults who wish to further their education and meet their professional and career aspirations.

RESEARCH AT NORTHEASTERN UNIVERSITY

Research and scholarship are integral parts of Northeastern University's commitment to the intellectual growth and academic achievement of its students. Research activities span almost every academic field and include laboratory projects, theoretical studies, and technological applications.

Funding for research comes from government agencies, foundations, corporations, and the University itself. In recent years such industrial firms as Beckman, General Electric, Digital, and Lockheed have supported Northeastern's research programs. Currently, external grants and contracts exceed $27.5 million annually.

Northeastern's faculty numbers among its ranks some of the most distinguished scholars in their fields, and many have received such prestigious awards as Sloan Scholarships, Guggenheim Fellowships, National Institutes of Health Research Awards, Fulbright Scholarships, and a MacArthur Foundation grant. Faculty members lecture the world over, serve as consultants to industry and government agencies, participate on a variety of national and international committees, and are quoted frequently in the regional and national press on a wide range of subjects.

University Institutes and Research Centers

Northeastern University operates a number of institutes and research centers to foster research efforts in areas that cross disciplinary boundaries. Some key units are:

-Center for Applied Social Research
-Barnett Institute of Chemical Analysis and Materials Science
-Electron Microscopy Center
-Electronics Research Laboratory
-Center for Labor Market Studies
-Marine Science and Maritime Studies Center
-Center for Communications and Digital Signal Processing
-Center for Electromagnetics Research
-Center for Medical Manpower Studies
-Center for the Study of Sport in Society
-Cooperative Education Research Center
-Biotechnology Engineering Center

NORTHEASTERN UNIVERSITY IN BOSTON

The city of Boston has played a pioneering role in American education. Today it has one of the largest and most diverse student populations in the country. Within a 25 mile radius of Northeastern University's campus are over 50 degree-granting institutions.

As a graduate student at Northeastern University, you will discover that part of the adventure of studying in Boston is exploring the cultural, educational, historical, and recreational offerings. Boston is one of Northeastern's richest resources.

Boston is both a city of tradition and a city of change. Centuries-old meeting houses are located beside striking contemporary office buildings and large-scale civic projects. This diversity is reflected in the cultural life of the city as well. Within a short distance of the main campus are numerous renowned cultural centers including Symphony Hall, the Museum of Fine Arts, the Isabella Stewart Gardner Museum, Horticultural Hall, and the Boston Public Library. Theater in Boston includes everything from pre-Broadway tryouts to experimental and college productions.

For those interested in sports, the Boston Red Sox, Boston Celtics, Boston Bruins, and New England Patriots play all their home games in and around Boston.

The University is adjacent to the Fenway, a spacious and naturalistic park designed near the turn of the last century by Frederick Law Olmsted, the world famous landscape architect, and includes a beautiful rose garden and paths used extensively by Northeastern joggers.

Cape Cod and the North Shore are easily reached by car or public transportation for swimming, surfing, and boating. The scenic areas of northern New England are accessible for skiing, hiking, and mountain climbing.

Boston provides students with a stimulating environment in which to learn and grow. In turn, the considerable influence of Boston's universities, colleges, and student populations provides a vibrant and exciting ambience, quite possibly unequalled anywhere else.

FINANCIAL INFORMATION

Tuition and Fees

The tuition rate for students enrolled in the Graduate School of Engineering for the 1992-93 (1993-94 figures unknown at printing) academic year was $320 per quarter hour of credit. Doctoral candidates making active use of University resources are charged an additional $600 per quarter residency for three quarters. A continuation fee, equivalent to the tuition cost for one-half of one quarter hour of credit for Master of Science and Engineer Degrees and one quarter hour of credit for Doctorates, is charged to students who have completed their course requirements but not their thesis requirements.

Tuition statements are mailed to students by the Bursar's Office and are payable by cash or check to Northeastern University on or before the date specified.

Other fees include a charge of $75 for late payment of tuition, a nonrefundable University Health Service fee of $525 each year for full-time students, and a Student Center fee of $12.50 per quarter for full-time students, and $.75 per quarter for part-time students enrolled in courses on the Boston campus. A one-time fee of $100 is charged to new international students upon their acceptance to Northeastern.

Complete information regarding tuition and fees is provided in the current brochure ***Student Financial Information.*** In cases where the student defaults on his/her tuition, the student shall be liable for the outstanding tuition and all reasonable associated collection costs incurred by the University, including attorney's fees.

Information on tuition refund and procedures for withdrawal from courses is provided in section A5 under the Academic Policies and Procedures section of this student catalog.

FINANCIAL ASSISTANCE

Northeastern University offers graduate students a variety of means for obtaining financial assistance. In addition to various types of assistantships awarded by the individual graduate schools, the Office of Financial Aid administers several forms of financial aid. A limited number of fellowships are also available to minority students through the African-American Institute, and each year there are also part-time residence hall staff positions available.

Graduate Assistantships

Of special interest to full-time graduate students are the variety of assistantships and fellowship programs. Awards are based on a student's previous academic performance. Assistantship applications are available from the Graduate School of Engineering Office. *Teaching and Administrative Assistantships* currently offer a $9,000 stipend and a $7,200 tuition scholarship for a nine-month (September to June) appointment. These awards require the performance of teaching or administrative functions for approximately twenty hours a week.

Research Fellowships for Master of Science degree and doctoral candidates, including National Institutes of Health and National Science Foundation grants, are offered through a number of departments. Graduate students who perform research work for the department usually receive a compensatory stipend of $9,000 (current amount) for a nine-month appointment in addition to tuition remission.

Northeastern University Tuition Assistantships (NUTA) provide up to $7,200 (based on current tuition rate of $300/qh) in tuition remission. The nine-month appointment is in exchange for ten hours per week of work.

Acceptance Conditions for Graduate Assistantships

Northeastern University, which is a member of the Council of Graduate Schools of the United States, subscribes to the following resolution of the Council: Acceptance of an offer of financial aid (such as a graduate scholarship, fellowship, traineeship, or assistantship) for the next academic year by an actual or prospective graduate student completes an agreement which both student and graduate school expect to honor. In those instances in which the student accepts the offer before April 15 and subsequently desires to withdraw, the student may submit in writing a resignation of the appointment at any time through April 15. However, an acceptance given or left in force after April 15 commits the student not to accept another offer without first obtaining a written release from the institution to which a commitment has been made. Similarly, an offer by an institution after April 15 is conditional on presentation by the student of the written release from any previously accepted offer.

Financial Aid Programs

The Office of Financial Aid offers several types of assistance to graduate students. All awards are based on financial need. Since these awards are sponsored by the Federal Government, the amount of aid granted is dependent upon the amount of funds allocated to Northeastern University each year.

In order to meet application deadlines for financial aid, students may have to apply for financial aid before they have been offered admission to the Graduate School. However, only those students who are accepted will be reviewed for financial aid. In addition, the University only awards financial aid to students who are U.S. citizens and permanent residents of the United States. International students are not eligible for federal assistance.

In addition to citizenship requirements, the federal government places regulations on course loads. Aid recipients who also hold a Northeastern University Tuition Assistantship (NUTA) must maintain a minimum course load of eight quarter hours per quarter. Stipended Graduate Assistantship (SGA) recipients must register for a minimum of six quarter hours per quarter. Part-time students are required to register for 6 quarter hours per quarter, and full-time students not holding an assistantship must carry 8 quarter hours per quarter. An aid recipient who does not maintain the proper course load runs the risk of having the amount of his or her aid package reduced.

Northeastern University requires that all applicants for financial aid (including loans) file a FAFSA in order to be eligible for consideration. The Graduate/Law Financial Aid application and transcripts of financial aid history from other schools attended are also required. All financial aid application forms are available from the Financial Aid office, 375 Richards Hall, Northeastern University, Boston, MA 02115. The telephone number is (617) 373-5899.

Federal Perkins Loans

This program is available to full-time graduate students who show a high level of financial need. Graduate students may borrow up to $18,000 during the course of their entire educational careers. Repayment and interest do not begin until 9 months after the student ceases to carry at least a half-time academic load. Repayment may be extended over a ten year period with an interest rate of five percent per annum. No payments are required for up to three years while a borrower is serving in the Armed Forces, Peace Corps, VISTA, or while working as a full-time volunteer for a tax-exempt charitable organization performing service comparable to the service performed in Peace Corps or VISTA.

Federal College Work-Study Program

This program is available to full-time graduate students who show financial need. It is designed to give students an opportunity to earn as much as $8.00 per hour working on jobs on or off campus in public or private nonprofit organizations. This program is administered solely by the Office of Financial Aid and should not be confused with the University's Cooperative Education Program.

Federal Stafford Student Loan (SSL) Program (formerly the Guaranteed Student Loan)

Under this program, students who demonstrate financial need, in accordance with guidelines established by the U.S. Department of Education, may borrow money for educational expenses from banks or other private lending institutions. Financial need is determined by the Financial Aid Office at Northeastern on the basis of information provided on the FAFSA. To be eligible for these loans, students must also be enrolled in a degree-granting program on at least a half-time basis.

The maximum annual borrowing limit is $7,500 and the aggregate limit (including SSL's borrowed at the undergraduate level) is $54,750. Information on specific terms, interest rates, conditions, fees and repayment, as well as application forms, may be obtained from lending institutions and state guarantee agencies. You may also contact the Office of Financial Aid at Northeastern.

Please Note: Students must receive a financial aid award letter from the Office of Financial Aid before submitting the SSL application form to the Student Loan Office at Northeastern.

Scholarships

Northeastern University Minority Fellowships (NUMF) are to assist a limited number of minority students accepted for full-time study in the Graduate Schools of the University. The awards are made to students who demonstrate superior academic achievement and are competitive within each graduate school. Stipends cover tuition and fees.
Martin Luther King, Jr. Scholarships. A limited number of full-time Martin Luther King, Jr., Scholarships are available. These scholarships pay the recipient's full tuition and fees during the course of satisfactory graduate work. Further information and applications are available at the African-American Institute, Northeastern University, 40 Leon Street, Boston, Massachusetts 02115.

Residence Hall Staff Positions

A limited number of residence staff positions in housing facilities are available each year. Appointments carry a minimum compensation of room and board. Further information may be obtained from the Residential Life Office, 104 Ell Building.

Graduate Cooperative Education

The Graduate Program in Engineering offers the opportunity for Cooperative Education. The number of offerings available to domestic students is limited and there are further restrictions international student placements. Students in the cooperative plan of graduate education may follow either an alternating or a parallel schedule, according to availability. In either program a minimum of eighteen months is required to compete the Master of Science degree program.

The alternating schedule is sequenced to include full-time co-op employment for three- or six-month periods interspaced with periods of classroom study on a full-time academic schedule of twelve to fourteen quarter hours minimum each quarter. The parallel schedule allows the graduate student to work simultaneously, for approximately twenty hours per week, while carrying a minimum academic load of eight quarter hours per quarter.

GRADUATE SCHOOL OF ENGINEERING

GENERAL INFORMATION

The Graduate School of Engineering offers degree programs designed to help students prepare themselves for technical positions in industrial organizations, government laboratories, research laboratories, and educational institutions.

In addition to extensive day graduate programs, the Graduate School of Engineering offers Master of Science, Engineer Degree, and Doctoral Degree programs on a part-time basis in the evening. An interdisciplinary Doctor of Philosophy is also available for graduate students whose interests overlap two or more departments. All full-time day graduate programs in the five departments are offered at the Boston campus. The evening graduate programs offered through the Department of Electrical and Computer Engineering and the Department of Industrial Engineering and Information Systems are available at both the Boston campus and the suburban Burlington campus. The other three departments offer their evening graduate programs at the Boston campus only.

Northeastern University awards credit on a quarter-hour basis, with one quarter-hour credit roughly equivalent to three-fourths of a semester hour. The Master of Science degree requires a minimum of forty to forty-eight quarter-hour credits, depending on the specific program selected. In some cases, depending upon academic background, prerequisite courses are required. Part-time students who normally carry four quarter hours each term can generally complete their programs in three and a half to four years, while full-time students, who may take twelve to sixteen quarter hours each term, may earn their degrees in as little as one year. However, full-time students receiving some form of tuition assistantship or who are enrolled in the co-op plan or the Master of Science in Information Systems program must usually devote two years to completing their academic requirements.

The Master of Science degree with specification is granted to students who have earned a baccalaureate degree in the same engineering discipline as their graduate program. However, students who are admitted to the Industrial Engineering and Information Systems Department are exempted from this general policy and may earn the specified degree regardless of their undergraduate training. Students holding undergraduate degrees in disciplines that do not correspond to their graduate program or that have been conferred by colleges outside the United States are awarded the Master of Science degree without specification upon completion of their program requirements.*

*In some cases, the specified degree in Civil Engineering is granted to students who hold undergraduate degrees from overseas institutions.

SPECIAL PROGRAMS IN ENGINEERING

Women in Engineering

The Women in Engineering Program offers the opportunity for educational preparation to women who seek advanced professional positions in the field of electrical or computer engineering, but who lack the necessary background. The program leads to a Master of Science degree with a concentration in computer engineering, or in some cases to the Master of Science in Electrical Engineering degree. It is designed for women with undergraduate degrees in nonengineering areas such as mathematics, physics, natural science, and mathematics or science education. Graduate study is offered on a full- or part-time basis.

An individual educational program is developed for each student. The program includes a transitional educational experience designed to provide students with Master of Science degree program prerequisites. The Women in Engineering Program also sponsors a series of career development seminars and other support services that address issues of specific interest to women planning a new career in engineering.

Women in Information Systems

The Women in Information Systems Program leads to a Master of Science in Information Systems degree. The program is designed for professional women with nontechnical degrees who seek the opportunity for a career move into the computer industry.

The program's goal is to provide a complete career transition in a short time frame by building new technical skills on the knowledge and professional experience base that students have previously acquired. The program begins with an initial full-time academic commitment of six months. Students are then offered help in locating co-op jobs where they will be expected to work forty hours a week earning industry-competitive, entry-level salaries while completing their Master of Science degree on a part-time basis. The entire program is designed to take two and one-half years to complete.

Industrial Fellowship Program

The Industrial Fellowship Program is a one-year Master of Science program in electrical and computer engineering. Students are selected and sponsored by their companies to attend a full-time graduate program for two to three days a week while retaining their full-time employment on the remaining days. The program is completed with a thesis in the summer months. The thesis topic is directly related to company work and is jointly supervised by an industrial manager and an academic advisor.

Instructional Television Fixed Service

Daytime graduate courses in electrical engineering, mechanical engineering, and industrial engineering and information systems are broadcast live to companies that are members of Network Northeastern. An interactive audio system is a unique linkage feature between the classroom and the ITFS student. The ITFS program is geared to the part-time graduate student in industry. A student may also pursue evening classes at either the Boston campus or the suburban Burlington campus.

DEGREE PROGRAMS IN ENGINEERING

Department of Chemical Engineering

Master of Science in Chemical Engineering or Master of Science (unspecified)
Doctor of Philosophy

Department of Civil Engineering

Master of Science in Civil Engineering or Master of Science (unspecified)
- Construction Engineering
- Environmental Engineering
- Geotechnical Engineering
- Public Works Engineering Management
- Structures and Materials
- Transportation Engineering

Doctor of Philosophy

Computer Systems Engineering

CAD/CAM
Engineering Software Design
Robotics

Department of Electrical and Computer Engineering

Master of Science in Electrical Engineering or Master of Science (unspecified)
- Computer Engineering
- Communications and Signal Processing
- Control and Signal Processing
- Electronic Circuits and Semiconductor Devices
- Electromagnetics, Plasma and Optics
- Power Systems

Electrical Engineer
Doctor of Philosophy

Department of Industrial Engineering and Information Systems

Master of Science in Industrial Engineering
- Computer and Information Systems
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Engineering Management
- Computer and Information Systems
- General Program
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Information Systems
Doctor of Philosophy
Industrial Engineer

Department of Mechanical Engineering

Master of Science in Mechanical Engineering or Master of Science (unspecified)
- Materials Science and Engineering
- Mechanics
- Thermofluid Engineering

Mechanical Engineer
Doctor of Philosophy

INTERDISCIPLINARY DOCTOR OF PHILOSOPHY

The Graduate School of Engineering offers the opportunity for an interdisciplinary doctoral program involving substantial work in two or more departments. A written proposal describing the areas of proposed study and research should be submitted with the student's application. Interdisciplinary study requires favorable recommendation by the sponsoring doctoral degree-granting department and approval by authorized representatives of the graduate study committees of the departments appropriate to the disciplines covered by the student's proposal. The sponsoring department is the registration base of the student.

Formation of Interdisciplinary Committee

A student who has been accepted for interdisciplinary study must obtain the consent of an advisor who will direct his or her doctoral thesis. This advisor, who may or may not be a member of the registration department, will be chairman of the interdisciplinary committee for this student. A second member will be appointed from the registration department by its chairman. These two members will obtain one or more additional members or request the director of the graduate school to do so. At least two departments must be represented on the committee, and a majority of the committee must come from doctoral degree-granting departments. The chairman of the registration department will notify the Director of the Graduate School of the membership of the committee as soon as arrangements are complete.

Duties of Interdisciplinary Committee

A member of the interdisciplinary committee who is also a member of the registration department will serve as the registration officer to approve the course registration for the student. A copy of the approved course registration must also be filed with the other committee members and with the graduate study committee of the registration department.

The interdisciplinary committee will be responsible for the administration of the qualifying examination, language examination, approval of the dissertation, and comprehensive examination. This committee must also certify to the registration department the completion of the requirements for the award of the doctoral degree.

The interdisciplinary committee must assure that the program of the student represents standards comparable to those of the registration department and that the program is not so broad that it has inadequate depth in any area.

The program of the student may be reviewed at any time by the Director of the Graduate School to determine whether objectives of the program are being met.

DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering offers the degrees of Master of Science in Chemical Engineering, Master of Science without specification, and Doctor of Philosophy. The Master of Science degree in Chemical Engineering may be pursued on either a full-time or a part-time basis. A full-time student may apply for participation in the Cooperative Plan. The Master of Science degree without specification must be pursued on a continuous full-time basis. The Doctor of Philosophy degree is pursued on a continuous full-time basis consistent with the residence requirements for the degree.

Full-time Master of Science students and Doctoral candidates are able to select thesis topics from a diverse range of faculty research interests. Graduate student seminars are held on a regular basis and provide an interactive forum for learning about departmental research and exchanging ideas. Most courses are offered in the late afternoon or early evening to make them readily accessible to part-time students pursuing full-time industrial careers.

Master of Science students wishing to switch their status from part-time to full-time must notify the Chemical Engineering Department and make formal petition to the Graduate School of Engineering. Such requests are usually granted for the full-time program to begin in the fall quarter. Please refer to the regulations of the Graduate School of Engineering for information on academic and administrative policies.

Master of Science Degree Requirements

A minimum of 40 quarter hours of academic work is required of all students. A thesis of ten quarter hours of credit and one seminar course are required of all continuous and cooperative full-time students who qualify for the Master of Science in Chemical Engineering, in addition to the required courses. All MS students must present a seminar on their thesis work to at least three department faculty before final acceptance. The sequence of courses which students take on this plan is established by their advisor. Part-time students may progress according to their abilities within the seven year time limit. A minimum of 44 quarter hours of academic course work is required for part-time students. The thesis and seminar course are not required for part-time students and unspecified Master of Science degree candidates.

A Master of Science in Chemical Engineering will be awarded to those students with a Bachelor of Science in Chemical Engineering or a closely-allied engineering field. Students with a Bachelor of Science degree in other engineering or related science fields and an appropriate background of preparation may qualify for the degree of Master of Science with specification. Such students are required to complete supplementary undergraduate work, which is not included in the minimum course requirements, on a full-time (non-cooperative education) basis.

Course Requirements

	Thesis Option	Non-Thesis Option
Required Core Courses	12 QH	12 QH
Master of Science Thesis	10 QH	0 QH
Seminar	2 QH	0 QH
Elective Courses**	16 QH	32 QH
Minimum Quarter Hours Required*	40 QH	44 QH

* exclusive of any preparatory courses

** Students may complete a maximum of 10 QH (Thesis Option) or 12 QH (Non-Thesis Option) of course work outside of the Chemical Engineering Department with approval of the Chemical Engineering Department

Required Core Courses (2QH equivalents are in parentheses)

			Credits
CHE	3300	(3301,3302) Chemical Engineering Mathematics	4
CHE	3310	(3311,3312) Chemical Engineering Thermodynamics	4
CHE	3320	(3321,3322) Separation Processes	4
CHE	3330	(3331,3332) Chemical Process Control	4
CHE	3400	(3401,3420) Adv. Chemical Engineering Calculations	4
CHE	3540	(3541,3542) Advanced Process Design Concepts	4

Master of Science Thesis CHE 3860 (3861,3862) 10
Seminar CHE 3691 2

Elective Courses

CHE	3340	(3341,3342) Heterogeneous Catalysis	4
CHE	3350	(3351,3352) Chemical Process Heat Transfer	4
CHE	3410	(3411,3412) Numerical Techniques in Chemical Eng'g	4
CHE	3430	(3431,3432) Chemical Data Estimation	4
CHE	3450	Analytical and Numerical Techniques	4
CHE	3500	(3501,3502) Transport Phenomena	4
CHE	3510	(3511,3512) Modeling and Simulation of Chemical Proc	4
CHE	3520	(3521,3522) Computer Process Control	4
CHE	3530	(3531,3532) Adv. Management Techniques in Chem. Ind	4
CHE	3543	Advanced Plant Design Concepts	2
CHE	3560	(3561,3562) Fluid Mechanics	4
CHE	3600	(3601,3602) Polymer Science	4
CHE	3620	(3621,3622) Principles of Polymerization	4
CHE	3630	(3631,3632) Chemical Process Pollution Control	4
CHE	3660	Solar Energy Thermal Processes	2
CHE	3663	(3664,3665) Fundamentals of Polymer Processing	4
CHE	3670	(3701,3702) Special Topics in Chemical Engineering	4
CHE	3671	(3672,3673) Kinetics of Chemical Processes	4
CHE	3680	Corrosion Fundamentals	2

The Doctor of Philosophy Degree

The Chemical Engineering Department offers the degree of Doctor of Philosophy on a continuous full-time basis. The following sections constitute the requirements for the doctoral program. Each student admitted to the program will initially have the status of *Doctoral Student.* A doctoral student who has completed the equivalent of an MS program in chemical engineering or 40 quarter hours of graduate work with satisfactory grades may become a *Doctoral Candidate* upon successful completion of the *Doctoral Qualifying Examination.* After candidacy has been established, a candidate must complete a dissertation under the direction of a Dissertation Advisor and a program of academic course work. To receive a Ph.D. degree a candidate must also pass a *Final Oral Examination.*

Qualifying Examination

Successful completion of the Doctoral Qualifying Examination is the minimum required for consideration as doctoral degree candidate. The qualifying examination includes both written and oral parts. The written part is normally given in the winter quarter. The oral examination will test general comprehension and is normally given at the time of the dissertation topic proposal presentation. The written examination, in general, will cover the following areas: Thermodynamics, Kinetics and Reactor Design, Process Control, Unit Operations (including Transport Phenomena), Process Design, and Applied Chemistry.

Course Requirements

A minimum of 60 quarter hours of academic course work beyond the bachelor of science degree in chemical engineering is required. The 60 quarter hours must include, at least, 24 quarter hours of academic course work (exclusive of thesis and seminars) taken at Northeastern University. All of the core courses for the specified masters degree must be included in the students academic graduate course work. The course requirements, in addition to the minimum requirements for establishing degree candidacy, will be determined by the departmental graduate committee.

Language Requirement

There is no foreign language requirement for the Doctor of Philosophy degree. The candidate must be proficient in technical writing and oral presentation in the English language. Appropriate course work may be required by the departmental graduate committee.

Residence Requirement

The residence requirement is satisfied by completing one academic year of full-time graduate studies during 3 consecutive academic quarters after successful completion (passing) of the Doctoral Qualifying Examination. Additional academic course work (exclusive of thesis and seminars) may be required and completed during this period. However, it is expected that at least two years of full-time graduate study will be required beyond the Master of Science degree.

Dissertation Prospectus/Outline

After passing the qualifying examination, the doctoral degree candidate must prepare a dissertation prospectus/outline depicting the research on an engineering problem which will be conducted, analyzed and presented in the dissertation. The cover sheet is signed by each member of the dissertation committee to indicate approval of the topic and its plan of execution.

Comprehensive Examination

The comprehensive examination is combined with the final oral examination and is given after the dissertation has been completed and approved by the dissertation advisor. This examination is based upon a defense of the subject matter of the dissertation.

Final Oral Examination

The final oral examination is taken after completion of all other requirements for the degree. The final oral examination will include the subject matter of the doctoral dissertation and significant developments in the field of the dissertation work. Other fields may be included if recommended by the examination committee.

Dissertation

After degree candidacy has been established, a candidate must complete a dissertation which embodies the results of extended original research and includes material suitable for publication. An individual may choose his or her dissertation topic and supervisor upon becoming a doctoral student. In most cases selection of topic will be made immediately after the student has established candidacy for the Ph.D. degree. The student will be expected to discuss Ph.D. dissertation topic offerings with the faculty. After these discussions, the student shall notify the advisor, the department head, and the chairman of the departmental graduate committee in writing of his or her choice of dissertation topic and advisor. The chairman of the departmental graduate committee, after consultation with the advisor, shall appoint an appropriate *Doctoral Dissertation Committee*. This committee shall be kept informed of the progress of the dissertation and will approve the dissertation in its final form.

Faculty

Ralph A. Buonopane, Chairman

Professors

Williams, John A., PhD, Case Western Reserve University; fuels
Wise, Donald L., PhD, University of Pittsburgh; biotechnology, biomaterials, bioconversions

Associate Professors

Buonopane, Ralph A., PhD, Northeastern University; heat and mass transfer
Goodwin, Bernard M., ScD, Massachusetts Institute of Technology; computer applications, applied math
Stewart, Richard R.,PhD, Clemson University; process control
Willey, Ronald, J., PhD, University of Massachusetts, Amherst; heterogeneous catalysis

Assistant Professors

Barabino, Gilda A., PhD, Rice University; biomedical/biochemical

Advisors

MS Specified	(A-L) Prof. Stewart (M-Z) Prof. Goodwin
MS Unspecified	(A-Z) Prof. Buonopane
PhD Program	(A-Z) Prof. Williams

CHEMICAL ENGINEERING COURSES

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine the courses that are actually offered in any given quarter and the day and time.

CHE 3300 Chemical Engineering Mathematics (4QH)
Fall Quarter, Alternating Years
Formulation and solution of problems involving advanced calculus as they arise in chemical engineering situations. Methods covered will include ordinary differential equations, series solutions, complex variables. Laplace transforms, partial differential equations, and matrix operations. Emphasis will be placed on methods for formulating the problems. It will be assumed that the student has been exposed to some of these topics in appropriate mathematics courses. Prep. BS degree in Chemical Engineering including mathematical analysis.

CHE 3301 Chemical Engineering Mathematics I (2QH)
Fall Quarter, As Announced
CHE 3301 and CHE 3302 cover the same material with the same prerequisites as CHE 3300, but in two 2QH courses.

CHE 3302 Chemical Engineering MathematicsII (2QH)
Winter Quarter, As Announced
Continuation of CHE 3301. Prep. CHE 3301.

CHE 3310 Chemical Engineering Thermodynamics (4QH)
Winter Quarter, Alternating Years
Classical thermodynamics as a method of approach to the analysis of processes of interest to chemical engineers. A study of phase equilibria involving the various states of matter; prediction and correlation of physical, chemical, and transport properties of gases and liquids; elementary concepts of quantum and statistical mechanics to interpret the empirical properties of classical thermodynamics. Fundamental principles are reviewed to the extent needed. Prep. BS degree in Chemical Engineering.

CHE 3311 Chemical Engineering Thermodynamics I (2QH)
Winter Quarter, As Announced
CHE 3311 and CHE 3312 cover the same material with the same prerequisites as CHE 3310, but in two 2QH courses.

CHE 3312 Chemical Engineering Thermodynamics II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3311. Prep. CHE 3311.

CHE 3320 Separation Processes (4QH)
Spring Quarter, Alternating Years
Calculation and design methods used in processes involving mass transfer. Topics covered include vapor liquid equilibria for binary and multicomponent systems, multicomponent distillation, absorption and extraction. Emphasis is placed on methods and techniques which are common to many separation processes. Prep. BS degree in Chemical Engineering.

CHE 3321 Separation Processes I (2QH)
Winter Quarter, As Announced
CHE 3321 and CHE 3322 cover the same material with the same prerequisites as CHE 3320, but in two 2QH courses.

CHE 3322 Separation Processes II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3321. Prep. CHE 3321

CHE 3330 Chemical Process Control (4QH)
Fall Quarter, Alternating Years
Review of classical control techniques; state variable representation and analysis of continuous control systems in chemical engineering, including controllability, observability, and stability. Multivariable control problems in chemical engineering; introduction to optimal control. Digital simulation included where appropriate. Prep. Graduate standing in Chemical Engineering or permission.

CHE 3331 Chemical Process Control I (2QH)
Fall Quarter, As Announced
CHE 3331 and CHE 3332 cover the same material with the same prerequisites as CHE 3330, but in two 2QH courses.

CHE 3332 Chemical Process Control II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3331. Prep. CHE 3331.

CHE 3340 Heterogeneous Catalysis (4QH)
Winter Quarter, Alternating Years
Experimental methods required for determining the surface area and pore structure of catalyst carriers are discussed. These structural characteristics are utilized to estimate mass and heat transport rates within porous catalysts in order to determine their effectiveness with respect to chemical reaction. Mechanisms for chemical poisoning of catalysts are also analyzed. Reactions of practical interest are used to illustrate the applications of heterogeneous catalysis to modern chemical processing problems. Prep. BS degree in Chemical Engineering.

CHE 3341 Heterogeneous Catalysis I (2QH)
Winter Quarter, As Announced
CHE 3341 and CHE 3342 cover the same material with the same prerequisites as CHE 3340, but in two 2QH courses.

CHE 3342 Heterogeneous Catalysis II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3341. Prep. CHE 3341.

CHE 3350 Chemical Process Heat Transfer (4QH)
Spring Quarter, Alternating Years
Empirical methods and calculations used to design heat transfer equipment for the chemical process industries. Review of basic heat transfer principles. Shell-and-tube calculations for liquid and/or vapor phase heat transfer. Direct contact and other special heat exchanger applications. Prep. BS degree in Chemical Engineering.

CHE 3351 Chemical Process Heat Transfer I (2QH)
Winter Quarter, As Announced
CHE 3351 and CHE 3352 cover the same material with the same prerequisites as CHE 3350, but in two 2QH courses.

CHE 3352 Chemical Process Heat Transfer II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3351. Prep. CHE 3351.

CHE 3400 Advanced Chemical Engineering Calculations (4QH)
As Announced
Fundamental process principles leading to an understanding of the stoichiometric principles of chemical process plants. The study of complex material and energy balances is undertaken with the view to apply these principles to actual large chemical plant conditions. Prep. BS in degree Chemical Engineering including differential equations.

CHE 3401 Advanced Chemical Engineering Calculations I (2QH)
As Announced
CHE 3401 and CHE 3402 cover the same material with the same prerequisites as CHE 3400, but in two 2QH courses.

CHE 3402 Advanced Chemical Engineering Calculations II (2QH)
As Announced
Continuation of CHE 3401. Prep. CHE 3401.

CHE 3410 Numerical Techniques in Chemical Engineering (4QH)
Fall Quarter, As Announced
Digital computer applications to chemical engineering problems. Topics covered include location of roots of linear and nonlinear equations, numerical integration, and curve-fitting techniques with emphasis on the numerical solution of ordinary and partial differential equations and on the subject of linear algebra. Prep. BS degree

CHE 3411 Numerical Techniques in Chemical Engineering I (2QH)
Fall Quarter, As Announced
CHE 3411 and CHE 3412 cover the same material with the same prerequisites as CHE 3410, but in two 2QH courses.

CHE 3412 Numerical Techniques in Chemical Engineering II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3411. Prep. CHE 3411.

CHE 3430 Chemical Data Estimation (4QH)
As Announced
Methods of obtaining physical and thermodynamic properties of chemical compounds and systems without resorting to laboratory investigation. Latest empirical relationships and physical and thermodynamics laws are introduced to obtain data for plant design and other chemical and engineering uses. Prep. BS Degree.

CHE 3431 Chemical Data Estimation I (2QH)
Fall Quarter, As Announced
CHE 3431 and CHE 3432 cover the same material with the same prerequisites as CHE 3430, but in two 2QH courses.

CHE 3432 Chemical Data Estimation II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3431. Prep. CHE 3431.

CHE 3450 Analytical and Numerical Techniques (4QH)
As Announced
For students interested in solving comprehensive problems using computer methods. Problems solved in the course will be based on the interest of the students and staff and will be individual. Prep. BS degree and knowledge of digital computer programming.

CHE 3500 Transport Phenomena (4QH)
Winter Quarter, As Announced
Momentum rate conservation equations for steady-state fluid flow in two-dimensional boundary layers are presented and solved to obtain the fluid velocity profiles. These results are utilized in the consideration of heat and mass transfer phenomena at a fluid-solid interface. The development of surface renewal theory is presented and applied to the description of heat and mass transfer phenomena. Prep. BS degree in Chemical Engineering.

CHE 3501 Transport Phenomena I (2QH)
Winter Quarter, As Announced
CHE 3501 and CHE 3502 cover the same material with the same prerequisites as CHE 3500, but in two 2QH courses.

CHE 3502 Transport Phenomena II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3501. Prep. CHE 3501.

CHE 3510 Modeling and Simulation of Chemical Process (4QH)
Winter Quarter, Alternating Years
Use of special purpose and general purpose computer programs in solving the steady-state material and energy balances of chemical processes. Includes related background material which may be applied to these computer programs such as convergence acceleration for calculations involving recycle streams, tearing recycle streams for iteration on minimum number of streams and minimum number of parameters, and algorithms for design variable selection. Prep. Graduate Standing in Chem. Engineering.

CHE 3511 Modeling and Simulation of Chemical Process I (2QH)
Winter Quarter, As Announced
CHE 3511 and CHE 3512 cover the same material with the same prerequisites as CHE 3510, but in two 2QH courses.

CHE 3512 Modeling and Simulation of Chemical Process II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3511. Prep. CHE 3511.

CHE 3520 Computer Process Control (4QH)
Winter Quarter, Alternating Years
Computer control hardware and software. Z-transform, pulse transfer functions, and data holds. Open and closed-loop response and design of sampled-data systems. Computer control algorithms. Digital simulation of sampled data systems. Prep. Graduate standing in Chemical Engineering or permission.

CHE 3521 Computer Process Control I (2QH)
Winter Quarter, As Announced
CHE 3521 and CHE 3522 cover the same material with the same prerequisites as CHE 3520, but in two 2QH courses.

CHE 3522 Computer Process Control II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3521. Prep. CHE 3521.

CHE 3530 Advanced Management Techniques in the Chemical Industry (4QH)
Fall Quarter, Alternating Years
Management techniques applied to the chemical

industry. Special attention to management of research organizations and to management of engineering services, such as design, computer, and related activities. Prep. Graduate standing.

CHE 3531 Advanced Management Techniques in the Chemical Industry I (2QH)
Fall Quarter, As Announced
CHE 3531 and CHE 3532 cover the same material with the same prerequisites as CHE 3530, but in two 2QH courses.

CHE 3532 Advanced Management Techniques in the Chemical Industry II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3531. Prep. CHE 3531.

CHE 3540 Advanced Process Design Concepts (4QH)
Spring Quarter, Alternating Years
Techniques and approaches used in the development of new or improved processes. Topics include establishment of process bases, use of process simulators in design, optimization and evaluation of alternatives, and preliminary equipment design and cost estimating techniques. Prep. BS degree in Chemical Engineering.

CHE 3541 Advanced Process Design Concepts I (2QH)
Fall Quarter, As Announced
CHE 3541 and CHE 3542 cover the same material with the same prerequisites as CHE 3540, but in two 2QH courses.

CHE 3542 Advanced Process Design Concepts II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3541. Prep. CHE 3541.

CHE 3543 Advanced Plant Design Concepts (2QH)
Spring Quarter, As Announced
Modern approaches to plant design: computer-oriented design, analysis and simulation of chemical processes, use of strategy decision making in design, advanced scheduling and planning techniques. Prep. BS degree in Chemical Engineering.

CHE 3560 Fluid Mechanics (4QH)
Fall Quarter, Alternating Years
Discussion of statics, kinematics, and stress concepts associated with fluids. Formation of the general equations of motion with application to laminar and turbulent flow. Topics on boundary layer theory and compressible flow are included. Prep. BS degree in Chemical Engineering.

CHE 3561 Fluid Mechanics I (2QH)
Fall Quarter, As Announced
CHE 3561 and CHE 3562 cover the same material with the same prerequisites as CHE 3560, but in two 2QH courses.

CHE 3562 Fluid Mechanics II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3561. Prep. CHE 3561.

CHE 3600 Polymer Science (4QH)
Fall Quarter, Alternating Years
Basic concepts of polymers, thermodynamics of polymer solutions and measurement of molecular weight. Physical and chemical testing of polymers. Crystallinity in polymers and rheology of polymers. Physical and chemical properties of polymers. Mechanisms and conditions for polymerization of polymers including step-reaction, addition and copolymerization. Discussion of carbon-chain polymers, fibers and fiber technology. Prep. BS degree in Chemical Engineering or Chemistry.

CHE 3601 Polymer Science I (2QH)
Fall Quarter, As Announced
CHE 3601 and CHE 3602 cover the same material with the same prerequisites as CHE 3600, but in two 2QH courses.

CHE 3602 Polymer Science II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3601. Prep. CHE 3601.

CHE 3620 Principles of Polymerization (4QH)
Fall Quarter, Alternating Years
Introduction to polymers and polymer properties. Mechanisms of polymerization including step po- lymerization, radical chain polymerization, emulsion polymerization, ionic-chain polymerization, chain copolymerization and ring-

opening polymerization. Stereo chemistry of polymerization and synthetic reactions of polymers. Applications to reactor design of industrially important polymers. Prep. Graduate standing in Chemical Engineering.

CHE 3621 Principles of Polymerization I (2QH)
Fall Quarter, As Announced
CHE 3621 and CHE 3622 cover the same material with the same prerequisites as CHE 3620, but in two 2QH courses.

CHE 3622 Principles of Polymerization II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3621. Prep. CHE 3621.

CHE 3630 Chemical Processes of Pollution Control (4QH)
Spring Quarter, Alternating Years
The basic fundamentals for handling environmental problems in the chemical process industries. Water quality requirements and industrial waste characteristics; wastewater treatment processes applicable to environmental engineering; biological treatment processes and equipment; comprehensive design problems involving biological and tertiary treatment; the economics of water treatment and reuse. Prep. Graduate standing in Chemical Engineering.

CHE 3631 Chemical Processes of Pollution Control I (2QH)
Winter Quarter, As Announced
CHE 3631 and CHE 3632 cover the same material with the same prerequisites as CHE 3630, but in two 2QH courses.

CHE 3632 Chemical Processes of Pollution Control II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3631. Prep. CHE 3631.

CHE 3660 Solar Energy Thermal Process (2QH)
Fall Quarter
Fundamental thermal processes involved in obtaining useful heat from flat-plate solar collectors. The components required in an active solar energy collection system are analyzed and the economics of the system are considered. Prep. BS degree.

CHE 3663 Fundamentals of Polymer Processes (4QH)
Winter Quarter, Alternating Years
Transport properties of polymer solutions and polymer melts. Modeling and design of polymer processing equipment. Flow models for processes involving heat, mass, and/or momentum transfer. Analysis of flow stability and elastic phenomena. Applications to the design of equipment for extrusion, calendering, coating, fiber spinning, tubular film blowing, injection molding and mixing. Prep. Graduate Standing in Chemical Engineering.

CHE 3664 Fundamentals of Polymer Processes I (2QH)
Winter Quarter, As Announced
CHE 3664 and CHE 3665 cover the same material with the same prerequisites as CHE 3663, but in two 2QH courses.

CHE 3665 Fundamentals of Polymer Processes II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3664. Prep. CHE 3664.

CHE 3670 Special Topics in Chemical Engineering (4QH)
As Announced
Topics of interest to the staff member conducting this class are presented for advanced study. A student may not take more than one Special Topics course with any one instructor. Prep. Permission of department staff.

CHE 3671 Kinetics of Chemical Processes (4QH)
Spring Quarter, Alternating Years
The theoretical foundations for the analysis of elementary chemical reaction rates, such as collision theory, particle dynamics, and transition state theory are presented. Consideration is given to the theory of monomolecular reactions and the effect of solvent and electrostatic forces on liquid phase reaction rates. Homogeneous catalysis and selected free-energy correlations are covered. Prep. BS degree in Chemical Engineering.

CHE 3672 Kinetics of Chemical Processes I (2QH)
Winter Quarter, As Announced
CHE 3672 and CHE 3673 cover the same material with the same prerequisites as CHE 3671, but in two 2QH courses.

CHE 3673 Kinetics of Chemical Processes II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3672. Prep. CHE 3672.

CHE 3680 Corrosion Fundamentals (2QH)
As Announced
Economic factors, basic theories, types, behaviors of specific systems, and protection against corrosion are studied. Wherever possible, engineering applications of the principles are emphasized. Prep. BS degree.

CHE 3691 Seminar (2QH)
Any Quarter
Topics of an advanced nature are presented by staff, outside speakers, and students in the graduate program. This course must be attended by all master's degree candidates. Prep. Graduate Standing in Chemical Engineering.

CHE 3701 Special Topics in Chemical Engineering I (2QH)
Any Quarter
Topics of interest to the staff member are presented for advanced study. A student may take this course and its continuation in CHE 3702 with the same instructor.

CHE 3702 Special Topics in Chemical Engineering II (2QH)
A continuation of CHE 3701

CHE 3796 DEng Continuation (0QH)
Any Quarter

CHE 3798 Masters Continuation (0QH)
Any Quarter

CHE 3799 PhD Continuation (0QH)
Any Quarter

CHE 3860 Thesis (Master's Degree) (10QH)
Any Quarter
Analytical and/or experimental work conducted under the supervision of the department. 10 QH maximum credit for thesis. Students normally register in CHE 3861 or CHE 3862. Prep. Graduate Standing in Chemical Engineering.

CHE 3861 Thesis (Master's Degree) (4QH)
Any Quarter

CHE 3862 Thesis (Master's Degree) (2QH)
Any Quarter

CHE 3880 Thesis (PhD Degree) (0QH)
Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Prep. Admission to doctoral program in Chemical Engineering.

CHE 3885 Thesis (DEng Degree) (0QH)
Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Prep. Admission to program in Chemical Engineering.

DEPARTMENT OF CIVIL ENGINEERING

The Department of Civil Engineering offers degree programs in construction management, environmental, geotechnical/geoenvironmental, structures and materials, and transportation engineering on the Master of Science and PhD levels. In addition, the department offers a Master of Science degree program in public works engineering management.

The Master of Science degree requirements may be completed on a full-time or part-time basis. In either case, the student must meet with his/her faculty advisor in the first quarter of study to arrange for an appropriate sequence of courses that will satisfy the degree requirements.

Master of Science Degree Requirements

A minimum of forty quarter hours of credit including four quarter hours for a Master of Science report or eight quarter hours for a Master of Science thesis with a minimum overall grade point average of 3.0 is required in all programs. With the approval of the department, graduate courses in other departments may be substituted for certain courses. Please refer to the regulations of the Graduate School of Engineering for information on academic and administrative policies.

Students holding a BSCE Degree who successfully complete program requirements will receive a Master of Science in Civil Engineering. An unspecified Master of Science degree will be awarded to those students who do not hold a BSCE.

Construction Management

The Construction Management program consists of required core courses primarily from the Civil Engineering Department, complemented by electives from Civil Engineering, the Department of Industrial Engineering and Information Systems, or from the Graduate School of Business Administration. Based on proven proficiency in given areas, certain required core courses may be waived and replaced with alternative courses. In addition to the required core, students choose one or a combination of the following program options: construction and engineering, systems engineering, and/or business management. Each student is required to prepare a program of study which must be reviewed and approved by a faculty advisor during initial registration. Courses taken in other colleges may have different credit hours; degree credit for those courses is granted on a course-for-course equivalency. Graduate courses not currently listed as technical electives may also be approved as technical electives by the student's advisor, provided they are consistent with the student's program.

Course Requirements

Master of Science	With Report	With Thesis
Required Core Courses	25 QH	25 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	12 QH	8 QH
Total Minimum Quarter Hours Required*	41 QH	41 QH

*exclusive of any preparatory courses

Required Core Courses

			Credits
	CIV 3131,3132	Engineering Statistics I & II	2 each
	CIV 3161	Systems Analysis I	2
	CIV 3231,3232	Construction Management I & II	2 each
	CIV 3241,3242	Legal Aspects of Civil Eng'g I & II	2 each
	CIV 3245	Construction Seminar	2
	CIV 3252	Construction Project Organization and Control	2
	ACC 3301	Financial & Managerial Accounting	3
or	ACC 3811	Financial Accounting	3
or	IIS 3101	Industrial Accounting for Engineers	2
	IIS 3615	Analysis & Design of Information Systems	4
	Master of Science Report CIV 3850		4
or	Master of Science Thesis CIV 3860		8

The remaining 12 or 8 elective coursework quarter hours must be selected from the following (electives do not have to be chosen from only one area of emphasis).

Construction and Engineering Emphasis

CIV 3237,3238	Construction Methods and Equip I & II	2 each
CIV 3410,3411	Soil Mechanics I & II	2 each
CIV 3420,3421	Foundation Engineering I and II	2 each
CIV 3520	Concrete Materials: Science & Technology	2
CIV 3559	Behavior of Reinforced Concrete Structures	2
CIV 3570	Steel Design	2

Business Management Emphasis

HRM 3301	Organizational Behavior	3
HRM 3972	Labor Relations	3
FIN 3301	Financial Analysis	2
IIS 3204	Engineering/Organizational Psychology	4
IIS 3207	Financial Management for Engineers	4

System Engineering Emphasis

CIV	3162	Systems Analysis II	2
IIS	3110	Pascal for Information Systems	4
IIS	3218	Planning & Managing Information Systems Development	4
IIS	3308	Micro-Computer Applications	2
IIS	3503	Simulation Methodology & Applications	4
IIS	3524	Multi-Criteria Decision Making	4
IIS	3525	Reliability Analysis and Risk Assessment	4
IIS	3604	Data Structures	4
IIS	3622	Information Systems in a Micro-computer Environment	4
IIS	3628	Database Management Systems	4
MSC	3301	Operations	2
MSC	3928	Decision Support Systems	3

Environmental Engineering

The Graduate Program in Environmental Engineering consists of required core courses and elective courses as described below. With the approval of the faculty advisor, students may take other graduate courses in civil engineering, in other engineering disciplines, or in other colleges at Northeastern. Courses carrying four quarter hours of credit meet during the day and are open to all students in the environmental engineering program.

Course Requirements

	With Report	With Thesis
Required Core Courses	20 QH	20 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	16 QH	12 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses (2 QH equivalents are in parentheses)

			Credits
CIV	3312	(3310,3311) Environmental Chemistry I & II	4
CIV	3318	(3315,3316) Water & Wastewater Treatment I&II	4
CIV	3321	(3322,3323) Environmental Biological Proc. I & II	4
CIV	3327	(3325,3326) Environmental Laboratory	4
CIV	3331, 3332	Environmental Computer Applic. I & II	2 each

Master of Science Report CIV 3850 4
or Master of Science Thesis CIV 3860 8

The remaining 16 or 12 quarter hours of elective coursework is to be selected from two elective groupings, environmental engineering and environmental science and may include other graduate courses with the approval of the student's faculty advisor.

Environmental Engineering

CIV	3317	Advanced Wastewater Treatment	2
CIV	3341	Industrial Waste Disposal	2
CIV	3343,3344	Process Lab in Environmental Eng'g I & II	2
CIV	3348	Stream Sanitation	2
CIV	3352	Open Channel Flow	2
CIV	3355	Hydrology I	2
CIV	3356	Hydrology II	2
CIV	3358	Flow Through Porous Media	2
CIV	3360	Groundwater & Seepage	2
CIV	3367	Water Resources Planning	2
CIV	3370	Air Pollution Engineering	2
CIV	xxxx	Other appropriate Civil Engineering course	2 or 4

Environmental Science

CIV	3372	Air Sampling and Analysis	2
CIV	3374	Air Pollution Science	2
CIV	3376	Industrial Hygiene	2
CIV	3378	Environmental Planning & Management	2
CIV	3380	Environmental Protection	2
CIV	3384	Solid Waste Management	2
CIV	3386	Hazardous Waste Practices	2

Geotechnical/Geoenvironmental Engineering

The Geotechnical Engineering program includes study in the areas of soil mechanics/ foundations and geoenvironmental. Beginning with a core of required courses providing a basic geotechnical background for all students, each student is able to select courses from both of the two elective areas in order to concentrate their professional interest. Geotechnical engineering students are also encouraged to select courses offered in the structural engineering program. Each student must meet with his/her faculty advisor at the beginning of his/her program to select an appropriate sequence of courses.

Course Requirements

	With Report	With Thesis
Required Core Courses	10 QH	10 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	26 QH	22 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

			Credits
CIV	3131	Statistics I	2
CIV	3358	Flow Through Porous Media	2
CIV	3410,3411	Soil Mechanics I & II	2 each
CIV	3420	Foundation Engineering I	2

SOIL MECHANICS / FOUNDATIONS

CIV	3237,3238	Construction Methods and Equipment I & II	2 each
CIV	3360	Groundwater and Seepage	2
CIV	3412	Stability and Seepage	2
CIV	3421	Foundation Engineering II	2
CIV	3422	Foundation Engineering III	2
CIV	3450	Engineering Geology	2
CIV	3470	Introduction to Dynamics and Earthquake Eng'g	2
CIV	3471	Soil Dynamics	2
CIV	3480	Seismic Design	2
CIV	3485	Earthquake Engineering	2

GEOENVIRONMENTAL TECHNOLOGY

CIV	3310,3311	Environmental Chemistry I & II	2 each
CIV	3325	Environmental Chemistry Laboratory	2
CIV	3326	Biological Processes Laboratory	2
CIV	3341	Industrial Waste Disposal	2
CIV	3348	Stream Sanitation	2
CIV	3355,3356	Hydrology I & II	2 each
CIV	3360	Groundwater and Seepage	2
CIV	3384	Solid Waste Management	2
CIV	3386	Hazardous Waste Practices	2
CIV	3450	Engineering Geology	2
CIV	3460	Landfill Design	2

ADDITIONAL ELECTIVES

CIV	3132	Engineering Statistics II	2
CIV	3241,3242	Legal Aspects of Civil Engineering I & II	2
CIV	3536	Structural Analysis	2
CIV	3546	Structural Dynamics	2
CIV	3141*	Numerical Methods in Civil Engineering	2
CIV	3530**	Finite Element Analysis of Structures	2

* ME 3411 equivalent
**ME 3481 equivalent

Public Works Engineering Management

The Public Works Engineering Management program requires a minimum of 40 quarter hour credits for graduation. These credits are in management and techinical core courses, technical electives, and project report. With the approval of the faculty advisor, students may take other graduate courses in civil engineering, in other engineering disciplines, or in other colleges at Northeastern. The course requirements are as follows:

Program Requirements

Required Management Core Courses	20	QH
Required Technical Core Courses	10	QH
Electives Courses	6	QH
Masters Report (2 QH Mgt and 2 QH Tech)	4	QH
Minimum Quarter Hours Required*	40	QH

* Exclusive of any preparatory courses

Required Management Core Courses

			Credits
CIV	3131	Engineering Statistics I	2
CIV	3241	Legal Aspects of Civil Engineering I	2
IIS	3615	Analysis and Design of Computer Information Systems	4
POL	3669	Labor Relations	2
POL	3603	Public Finance and Budget	2
POL	3602	Organizational Theory and Management	2
CIV	3171	Seminar in Public Works I	2
CIV	3172	Seminar in Public Works II	2
CIV	3252	Construction Project Control and Organization	2

Note: Courses taken in colleges other than Civil Engineering may have different credit hours; degree credit for those courses is granted on a course-for-course equivalency.

Required Technical Core Courses

CIV	3237	Construction Methods and Equipment I	2
CIV	3310	Environmental Chemistry I	2
CIV	3422	Foundation Engineering III	2
CIV	3460	Landfill Design	2
CIV	3520	Concrete Materials; Science & Technology	2
CIV	3640	Theory and Practice of Transportation Planning I	2

Elective Courses

These are selected from the listing of courses (see graduate catalog) in conjunction with the student's advisor.

Structures and Materials

The Structures and Materials program includes courses in the areas of structural mechanics, structural analysis and design, dynamics of structures and properties of solid materials.

Twenty-eight credit hours (24 in the Thesis option) must be taken from the list of core courses shown below. Other courses can be selected from any Civil Engineering graduate course offering. Each student must meet with his or her advisor in the first quarter of study to obtain advice and approval on a program that is best fitted to his/her interests and objectives.

Both the Master of Science and the Master of Science in Civil Engineering are awarded after the completion of 40 credit hours of work and satisfactory approval of the Masters Thesis in an oral presentation.

Course Requirements

	With Report	With Thesis
Core Courses	28 QH	24 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	8 QH	8 QH ***
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

*** These credits can also be selected from the list shown below

Core Course Selections

			Credits
CIV	3131,3132	Engineering Statistics I & II	2 each
CIV	3141*	Numerical Methods in Civil Engineering	2
CIV	3410,3411	Soil Mechanics I & II	2 each
CIV	3420	Foundation Engineering I	2
CIV	3470	Introduction to Dynamics & Earthquake Engineering	2
CIV	3471	Soil Dynamics	2
CIV	3480	Seismic Design	2
CIV	3485	Earthquake Engineering	2
CIV	3510,3511	Structural Mechanics I & II	2 each
CIV	3520	Concrete Materials: Science & Technology	2
CIV	3530**	Finite Element Analysis of Structures	2
CIV	3536	Structural Analysis	2
CIV	3546	Structural Dynamics	2
CIV	3559	Behavior of Reinforced Concrete Structures	2
CIV	3560	Prestressed Concrete	2
CIV	3561	Reinforced Concrete Slabs	2
CIV	3570	Steel Design	2
CIV	3571	Inelastic Steel Design	2
CIV	3575	Bridge Design	2
Master of Science Report CIV 3850			4
or Master of Science Thesis CIV 3860			8

* ME 3411 equivalent
**ME 3481 equivalent

Transportation Engineering

The Transportation Engineering Program is designed for students with career goals in transportation engineering, planning or research. This program may consist of courses from engineering, liberal arts, and/or business. In addition to the degree requirements stated at the beginning of the civil engineering section, students who do not meet a minimum twenty-four quarter hours in civil engineering courses will receive an unspecified Master of Science degree. With advisor approval, a maximum of three courses may be taken in non-technical fields (arts and sciences or business administration). Students should consult the appropriate catalogs for courses outside of engineering.

Course Requirements	With Report	With Thesis
Required Core Courses	12 QH	12 QH
Master of Science Report or Thesis	4 QH	8 QH
Technical Courses	18-24 QH	14-20 QH
Non-Technical Courses (equivalent to)	0- 6 QH	0- 6 QH
Minimum Quarter Hours Required *	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses

	Credits
CIV 3131,3132 Engineering Statistics I & II	2 each
CIV 3161,3162 Systems Analysis I & II	2 each
CIV 3640,3641 Theory & Practice of Transportation Planning I & II	2 each
Master of Science Report CIV 3850	4
or Master of Science Thesis CIV 3860	8

Technical Courses

CIV	3610	Urban Public Transportation 2
CIV	3630	Traffic Engineering 2
CIV	3635	Transportation Engineering 2
CIV	3650,3651	Urban Transportation Analysis I & II 2 each
IIS	3503	Simulation Methodology & Applications 4
IIS	3515	Queuing Theory 4
IIS	3531	Operations Research II 4
IIS	3615	Analysis and Design of Computer Information Systems 4

Non-Technical Courses **(count as 2 credits each when determining QH for degree)**

ECN	3363	Urban Economic Systems 3
ECN	3364	Urban Economic Development 3
ECN	3366	Economics of Inter-City Transportation 3
ECN	3371	Regional Development 3
ECN	3379	Development Planning Seminar 3
POL	3618	Problems in Urban Planning 3
TRN	3903	Corporate Logistics Management 3

The Doctor of Philosophy Degree

Award of the Doctor of Philosophy degree is based on exceptional performance in course work and evidence of ability to formulate and execute original research. The degree program has two components: (1) An academic program consisting of a set of graduate level courses which provide depth in a specific area of Civil Engineering (the major field) and additional exposure, at an advanced level, to one or more science disciplines (the minor field); and (2) the doctoral dissertation, an extended independent research effort on a relevant technical problem resulting in an original contribution.

Mastery of the subject matter is measured by a qualifying examination covering a subset of subjects selected from the major field. Research progress is monitored periodically by a Doctoral Dissertation Committee and the candidate is required to present and defend the research results before an expanded group of faculty and research staff at the completion of the work.

The doctoral program is deliberately designed to be flexible with respect to subject area since the PhD degree is primarily a "research" degree and therefore the program must be adaptable to changes in research needs.

Qualifying Examination and Degree Candidacy

The qualifying examination will consist of written and oral portions and its content will depend on the educational background and objectives of the student. In general, the written part will cover subject matter at the Master's level selected from the major field and will include: (1) basic engineering and science disciplines and (2) civil engineering application areas. The oral portion will measure general comprehension and aptitude for research. If the examination is failed, it may be repeated with permission of the PhD Committee. The qualifying examination must be taken no later than two years after admittance as a doctoral student. Upon successful completion of the examination and satisfaction of the general graduate school regulations, the student is classified as a doctoral candidate. Doctoral study must be completed within five years after classification as a doctoral degree candidate.

Course Requirements

A proposal defining the content of the academic program is developed jointly by the student and faculty advisor and then reviewed by the PhD Committee. Intellectual rigor, connectivity of subject matter, and compatibility with departmental interests are critical issues. Final approval is arrived at through discussion and represents a mutual agreement between the student and the PhD Committee. Flexibility in program definition is encouraged, especially in areas where complementary courses exist in other departments, or where expertise resides outside the Department and the objective is to introduce new technology in civil engineering practice.

The academic program must contain at least 72 quarter hours of graduate level course work, exclusive of seminars, special study research activities, and MS thesis and PhD dissertation

work. A minimum of 60 quarter hours must be related to the major field but can include courses from other departments when appropriate. The minor field must include a minimum of 12 quarter hours of course work in science disciplines of interest to civil engineers, e.g., mathematics, computer science, materials science, earth sciences, chemistry, biology, health sciences. Upon successful completion of the PhD qualifying examination and the majority of required coursework, the student is required to register in three consecutive quarters for CIV 3880 (PhD Thesis). Upon completion of this sequence, the student is required to register for CIV 3799 (PhD Continuation) in every quarter until the dissertation has been completed. Students may not register for continuation until the three-quarter thesis sequence has been fulfilled.

Transfer credit for students entering with a Master of Science Degree will be handled on an individual basis. A minimum of 28 QH of coursework beyond the MS degree must be completed at Northeastern.

Language Requirement

The candidate must be proficient in technical writing and oral presentation in the English language. Appropriate course work may be required by the PhD Committee.

Residence Requirement

Three successive quarters of full-time study on campus are required to establish residence. The total effort for a doctorate involves, as a minimum, three years of full-time work beyond the Bachelor's Degree. Candidates who enter the doctoral program with a Master of Science Degree may complete the requirements in less time, but they should anticipate at least two years of full-time effort.

Dissertation

Once degree candidacy has been established, the student is allowed to proceed with the dissertation effort. The candidate is required to generate a dissertation proposal and identify a civil engineering faculty member who will act as the dissertation advisor. A Dissertation Committee, consisting of the dissertation advisor and at least four other Northeastern faculty members, selected by the PhD Committee, will monitor progress and approve the final document.

Comprehensive Examination

The comprehensive examination consists of a defense of the doctoral research work and an examination on subject matter related to the dissertation area.

Faculty

Mishac K. Yegian, Chairman

Professors

Blanc, Frederic C., PE, PhD, New York University; wastewater; industrial, hazardous, and solid waste

Cochrane, John J., PE, PhD, Rensselaer Polytechnic Institute; treatment process design, computer-aided analysis and design, water quality management

Gregory, Constantine J., PhD, Rutgers University; air pollution control, environmental modeling, industrial hygiene

Leet, Kenneth M., PE, ScD, Massachusetts Institute of Technology; design and behavior of reinforced and prestressed concrete structures, high strength concrete, durabil ity of concrete

Yegian, Mishac K., PE, PhD, Massachusetts Institute of Technology; soil dynamics, earthquake engineering, risk analysis, geotechnical engineering, geosynthetics, seismic response of waste containments

Associate Professors

Bernal, Dionisio, PhD, University of Tennessee; earthquake engineering, structural engineering

Furth, Peter G., PhD, Massachusetts Institute of Technology; transportation analysis and planning, optimization, applied probability and statistics

Meserve, Robert L., PE, MS, Northeastern University; water and wastewater treatment, hydraulics, highways, surveying, environmental design

Schoon, John G., PE, PhD, Polytechnic Institute of New York; transportation analysis and planning, traffic engineering, highways and public works

Scranton, Richard J., MS, Massachusetts Institute of Technology; transportation systems, mechanics, applied probability

Wei, Irvine W., PhD, Harvard University; water chemistry, treatment processes, acid precipitation

Assistant Professors

Evans, Mark D., PE, PhD, University of California, Berkeley; geotechnical engineering, experimental soil mechanics, geosynthetics, waste containment systems

Krstulovic-Opara, Neven, PhD, Carnegie-Mellon University; fracture mechanics of cementitious materials, fiber reinforced composites, shape memory alloys

Medina, Daniel E., PhD, Cornell University; hydraulics, hydrology, groundwater flow, contaminant transport, numerical modeling

Sheahan, Thomas C., PE, ScD, Massachusetts Institute of Technology; geotechnical engineering, clay behavior, laboratory equipment automation, and measurement instrumentation

Touran, Ali, PE, PhD, Stanford University; construction engineering and management

Uang, Chia-Ming, PhD, University of California, Berkeley; steel design, seismic design, experimental investigation of structures

Advisors

	Part-time	Full-time
Construction	(A-Z) Prof. Touran	(A-Z) Prof. Touran
Environmental	(A-E) Prof. Gregory (F-J) Prof. Blanc (K-P) Prof. Cochrane (Q-Z) Prof. Wei	(A-Z) Prof. Blanc
Geotechnical	(A-Z) Prof. Evans	(A-Z) Prof. Sheahan
Public Works	(A-Z) Prof. Schoon	(A-Z) Prof. Schoon
Structural	(A-L) Prof. Uang (M-Z) Prof. Leet	(A-Z) Prof. Bernal
Transportation	(A-L) Prof. Schoon (M-Z) Prof. Furth	(A-Z) Prof. Schoon

CIVIL ENGINEERING

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered.
Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time.

CIV 3131 Engineering Statistics I (2QH)
Fall Quarter
The basic elements of probability theory and statistics and their use in the solution of various civil engineering problems. Probability of events, random variables and distributions, conditional probability, descriptive statistics, expectation, common probability models. Prep. Undergraduate calculus.

CIV 3132 Engineering Statistics II (2QH)
Winter Quarter
Continuation of CIV 3131. Includes parameter estimation, confidence intervals, hypothesis testing, sampling methods and linear statistical models. Prep. CIV 3131.

CIV 3141 Numerical Methods in Civil Engineering (2QH)
As Announced
Solution of simultaneous algebraic equations. Solution of large systems by direct and iterative methods. Finite-difference methods for ordinary and partial differential equations. Introduction to finite-element methods. Examples are drawn from fluid flow, geotechnical engineering, and structural mechanics. Prep. Admission to Graduate School of Engineering.

CIV 3161 Systems Analysis I (2QH)
Fall Quarter
Application of linear and dynamic programming models to various civil engineering problems: the simplex method, sensitivity analysis, transportation problem, transhipment problem, shortest path problem, allocation problems, inventory models. Prep. Admission to Graduate School of Engineering.

CIV 3162 Systems Analysis II (2QH)
Winter Quarter, Alternate Years
Non-linear optimization techniques, including integer programming, with applications to civil engineering problems such as resource allocation, traffic equilibrium on congested networks, and facility location. Prep. CIV 3161.

CIV 3171 Seminar in Public Works I (2QH)
Winter Quarter, Alternate Years
History and role of Public Works in development (topics include historical development, economic and financial dimensions of public works in city and state government, technological change, local, regional and national planning); Public Works capital development (topics include political, economic, financial, social, administrative and technical factors). Prep. Admission to Graduate School of Engineering.

CIV 3172 Seminar in Public Works II (2QH)
Spring Quarter, Alternate Years
Public Works applications in management science (topics include applications of benefit/cost, cost-effectiveness, allocation models, decision theory, queueing theory, simulation, etc.); Maintenance management (topics include inventory, performance standards, scheduling, budgets and finance); Public Works planning issues (topics include environmental assessment, techniques of land use planning and procedures, facility location and resource utilization.

CIV 3231 Construction Management I (2QH)
Fall Quarter
A presentation of all aspects of construction cost estimating; contracts, labor, equipment, material and indirect costs, conceptual estimating, detailed estimating and bid preparation, computerized cost estimating. Students will work on a cost estimating project as a part of the requirements. Prep. Admission to Graduate School of Engineering.

CIV 3232 Construction Management II (2QH)
Winter Quarter
Construction planning and scheduling with an emphasis on network-based scheduling systems, e.g. CPM and Precedence diagramming, resource leveling and allocation, time-cost trade off, PERT statistical approach, and introduction to network based project control. Students will use a software package as part of the requirements. Prep. Admission to Graduate School of Engineering.

CIV 3237 Construction Methods and Equipment I (2QH)
Fall Quarter
Selection and application of construction equipment; earthmoving equipment including excavators, bulldozers, scrapers, etc.; productivity analysis of equipment operations, construction equipment economics. Prep. Admission to Graduate School of Engineering.

CIV 3238 Construction Methods and Equipment II (2QH)
Spring Quarter, Alternate Years
Continuation of CIV 3237; Computer modeling of equipment production systems including truck-loader, scraper-tractor, simulation of equipment operations, belt-conveyer systems, bituminous pavements material and equipment, asphalt plants. Prep. CIV 3237.

CIV 3241 Legal Aspects of Civil Engineering I (2QH)
Fall Quarter
A presentation of U.S. and International legal systems and theories necessary for the comprehension of business and contractual liabilities, rights and obligations in the engineering field. Prep. Admission to the Graduate School of Engineering.

CIV 3242 Legal Aspects of Civil Engineering II (2QH)
Winter Quarter
Description and evaluation of various types of construction contracts, procedures and formats for submitting bids, filing claims, and legal steps to avoid liabilities, utilizing the principles learned in CIV 3241. Prep. CIV 3241.

CIV 3245 Construction Seminar (2QH)
Spring Quarter
A reading and discussion course centering on recent research publications in Construction Engineering. Prep. Limited to Construction Management Program majors.

CIV 3252 Construction Project Control and Organization (2QH)
Spring Quarter
Organization of construction firms, both at the general corporate level and at the project level. Organization dynamics designed to respond to the requirements of the environment given the internal constraints of the firm. Computer systems for the control of construction projects. Design attributes to fit the needs of the organization and the end users. Estimating, scheduling, budgeting and financial control of projects. Network-based systems for planning and time control. Intra-project and inter-project resource allocation. Data-base design concepts for decision support systems. Prep. CIV 3232

CIV 3310 Environmental Chemistry I (2QH)
Fall Quarter
A review of basic chemistry is followed by a discussion of the chemical kinetics and equilibrium chemistry of homogeneous and heterogeneous systems with applications in environmental engineering. The specific topics to be covered include physical and chemical properties of water, acid-base reactions, pH, alkalinity, equilibrium calculation using analytical and graphical methods, and coordination chemistry. The emphasis is placed on the quantitative evaluation of chemical changes in the environment. Prep. Two quarters of general chemistry.

CIV 3311 Environmental Chemistry II (2QH)
Winter Quarter
A continuation of CIV 3310, including the basic principles of chemical thermodynamics, reprecipitation-dissolution reactions, colloid chemistry, adsorption-desorption, redox reactions, and organic chemistry as they relate to environmental problems and engineering. Practical applications in water softening, coagulation, activated-carbon adsorption, and chlorination are discussed as are electrochemical measurements. Prep. CIV 3310; to be taken concurrently with CIV 3325.

CIV 3312 Environmental Chemistry I and II (4QH)
Fall Quarter
Embodies the material in CIV 3310 and CIV 3311. Prep. Two quarters of general chemistry.

CIV 3315 Water and Wastewater Treatment I (2QH)
Fall Quarter
Covers design principles and theory for pretreatment, sedimentation, coagulation, flocculation, chemical softening, filtration, activated carbon adsorption and disinfection. Prep. Undergraduate fluid mechanics.

CIV 3316 Water and Wastewater Treatment II (2QH)
Winter Quarter
A continuation of CIV 3315 including design principles involved in various biological treatment systems, oxygen transfer systems, solids thickening, aerobic digestion and anaerobic treatment systems. Prep. CIV 3315 and CIV 3323.

CIV 3317 Advanced Wastewater Treatment (2QH)
Spring Quarter
This course covers operational and design principles involved in sludge dewatering, biological nitrification and dentrification, phosphorus removal and other advanced treatment methods. Prep. CIV 3316.

CIV 3318 Water and Wastewater Treatment I and II (4QH)
As Announced
Embodies the material in CIV 3315 and CIV 3316. Prep. Undergraduate fluid mechanics.

CIV 3321 Environmental Biological Processes (4QH)
Winter Quarter
Embodies the subject matter of courses CIV 3322 and CIV 3323. Prep. Civ 3311.

CIV 3322 Environmental Biological Processes I (2QH)
Winter Quarter
A study of microbiology with emphasis on biological processes of importance in environmental engineering applications. Includes: cell structure, cell nutrition, morphology, microbial metabolism and kinetics as applied to biological treatment processes. Prep. CIV 3310, may be taken concurrently with CIV 3311.

CIV 3323 Environmental Biological Processes II (2QH)
Spring Quarter
A continuation of CIV 3322, which provides the student with biological wastewater treatment process, theory, eutrophication theory, as well as covering effects of toxins on microorganisms and disinfection theory. Prep. CIV 3322.

CIV 3325 Environmental Chemistry Laboratory (2QH)
Winter Quarter
A laboratory course emphasizing analysis related to important topic areas in environmental chemistry including alkalinity, hardness, acid-base reactions, chemical kinetics, precipitation reactions, chlorine and oxidation-reduction reactions. Prep CIV 3310; (may be taken concurrently with CIV 3311).

CIV 3326 Biological Processes Laboratory (2QH)
Spring Quarter
A laboratory course emphasizing analysis related to microbiological examination and other wastewater treatment parameters used to monitor the biological process such as: BOD, TOC, COD, gravimetric methods and dissolved oxygen. Prep. CIV 3325.

CIV 3327 Environmental Laboratory (4QH)
Fall Quarter
Embodies the material in CIV 3325 and CIV 3326. Prep. to be taken concurrently with CIV 3312.

CIV 3331 Environmental Computer Applications I (2QH)
Winter Quarter
Utilization of computers for the handling of environmental engineering data. Topics to be covered include: statistics, curve fitting, correlation, linear regression, spreadsheet data handling, BOD kinetics, chemical reaction interactions. Prep. Admission to Graduate School and familiarity with FORTRAN or BASIC.

CIV 3332 Environmental Computer Applications II (2QH)
Spring Quarter
A continuation of CIV 3331, this course covers the application of computer modeling and use of data base management systems to specific environmental problems and processes covering areas such as: reactor kinetics, stream and lake modeling, treatment plant performance modeling and stormwater management. Prep. CIV 3331.

CIV 3341 Industrial Waste Disposal (2QH)
Spring Quarter
Evaluation of industrial waste problems and development of process design for the required treatment facilities; study of various manufacturing processes and their wastewater problems; industrial waste survey techniques; characteristics of industrial wastes; evaluation of hazardous materials; waste reduction methods; physical, chemical, biological and advanced treatment methods; industrial wastewaters and disposal and treatment of industrial solids and liquids. Prep. CIV 3311 and CIV 3317 can be taken concurrently.

CIV 3343 Process Lab in Environmental Engineering I (2QH)
Winter Quarter
Laboratory scale unit operations illustrating the physical, chemical and biological principles involved in water and wastewater treatment. The aim is to obtain criteria for system design. Topics include disinfection, water softening, sedimentation, chemical coagulation, and ion exchange. Prep. CIV 3316 and CIV 3326 or CIV 3318 concurrently.

CIV 3344 Process Lab in Environmental Engineering II (2QH)
Spring Quarter, Alternate Years
A continuation of CIV 3343. Topics include biodegradability studies using activated sludge, fixed-film reactors, anaerobic digestion, vacuum filtration, and chemical-physical processes involved in wastewater treatment. A comprehensive evaluation of each unit process is required in a report from each student. Prep. CIV 3316 and CIV 3326.

CIV 3348 Stream Sanitation (2QH)
Winter Quarter
Analysis of the fate and effects of discharge of conservative and non-conservative pollutants in surface receiving waters and groundwaters. Topics include BOD and oxygen relationships in streams, eutrophication and general water quality improvement techniques. Prep CIV 3310.

CIV 3352 Open Channel Flow (2QH)
Fall Quarter, Alternate Years
Energy and momentum principles; uniform flow, channel design; gradually varied flow. Computation of hydraulic profiles in prismatic and non-prismatic channels; transition design; river mechanics. Prep. Undergraduate Fluid Mechanics and Hydraulic Engineering.

CIV 3355 Hydrology I (2QH)
Winter Quarter, Alternate Years
Hydrologic cycle, precipitation, evaporation, runoff, infiltration, groundwater. Mass and energy balance; hydrologic and hydraulic routing. Reservoir routing. Hydrograph analysis; rainfall-runoff relationships. Prep. Undergraduate Fluid Mechanics and Hydraulic Engineering.

CIV 3356 Hydrology II (2QH)
Spring Quarter, Alternate Years
Continuation of CIV 3355. Unit hydrograph; conceptual models; linear and non-linear analysis; probability and statistics in hydrology. Stochastic hydrology; frequency analysis; streamflow generation. Prep. CIV 3355.

CIV 3358 Flow Through Porous Media (2QH)
Fall Quarter
Soil-water interaction. Aquifers; Darcy's Law and groundwater flow. Dupuit-Forcheimer assumptions. Aquifer hydraulics and applications. Anisotropy. Potential flow. Well hydraulics. Principle of superposition. Method of images. Prep. Undergraduate Fluid Mechanics and Hydraulic Engineering.

CIV 3360 Groundwater and Seepage (2QH)
Winter Quarter, Alternate Years
Unsteady groundwater flow and well hydraulics. Pumping tests. Groundwater flow modeling. Finite-difference methods and applications. Finite-element methods. Contaminant transport.

Numerical modeling of contaminant transport. Prep. CIV 3358.

CIV 3367 Water Resources Planning (2QH)
Spring Quarter, Alternate Years
Water resources systems. Technical, legal, and political aspects; economic analysis; optimization problems; dynamic and linear programming. Objectives in planning; benefits and costs in water resources; deterministic modeling of river basin; planning under uncertainty. Stochastic modeling. Prep. Undergraduate course in Applied Probability.

CIV 3370 Air Pollution Engineering (2QH)
Winter Quarter
Theory and practice related to engineering management of air resources; applications of models for the atmospheric dispersion of pollutants; analysis of control systems for gaseous and particulate emissions utilizing dry collection, wet collection, absorption, and catalytic processes. Discussion of source control evaluation and air quality standards. Course CIV 3374 is recommended. Prep. Admission to Graduate School.

CIV 3372 Air Sampling and Analysis (2QH)
Spring Quarter, Alternate Years
Basic design considerations and requirements for air quality surveillance. Examination of the methodologies for air quality sampling, sampling frequencies, measurement techniques and data acquisition, handling and analysis. Manual and automated techniques are discussed for the evaluation of source and ambient systems. Statistical techniques are employed to evaluate air quality management strategies. Prep. CIV 3370.

CIV 3374 Air Pollution Science (2QH)
Fall Quarter
Biological and chemical aspects of air pollution with emphasis on the toxicological aspects of the environment, physiological effects of aerosols, analysis of organic and inorganic constituents of the atmosphere and rationale for establishment of air quality criteria and standards. Note: Open to non-engineering as well as to engineering graduate students. Prep. Consent of the department and instructor.

CIV 3376 Industrial Hygiene (2QH)
Winter Quarter, Alternate Years
Characterization and control of industrial problems associated with noise, heat and ventilation. Physical and biological aspects of environmental stress are discussed. Emphasis is placed on the application of engineering principles to the design of control systems. Evaluation procedures for control effectiveness are reviewed. Prep. Admission to Graduate School of Engineering.

CIV 3378 Environmental Planning and Management (2QH)
Fall Quarter, Alternate Years
Planning and operation, and management of specific environmental systems, such as collection systems, wastewater treatment systems, solid and hazardous waste management systems. Case studies, role-playing and computer simulation are utilized to analyze current environmental problems. Prep. Admission to Graduate School of Engineering.

CIV 3380 Environmental Protection (2QH)
Spring Quarter
Environmental quality and its effects on health, comfort, aesthetics, balance of ecosystems and renewable resources; interaction of the water-land-air complex, vector control, food protection, ionizing radiation, other radiation, and thermal and noise pollution. Prep. Admission to Graduate School of Engineering.

CIV 3384 Solid Waste Management (2QH)
Fall Quarter
Basic solid waste management for engineering and science students covering storage, collection practices, sanitary landfill principles, incineration practices and reclamation possibilities. Prep. Admission to Graduate School of Engineering.

CIV 3386 Hazardous Waste Practices (2QH)
Spring Quarter
Waste classification; regulatory aspects; site investigations; hydrogeologic characterization; sampling methods; soil and groundwater contamination. Fate and transport of contaminants; treatment technologies, pump-and-treat methods, carbon adsorption, in-situ vapor extraction and air sparging, air-stripping,

bioremediation, chemical treatment; innovative treatment technologies. Prep. CIV 3358.

CIV 3410 Soil Mechanics I (2QH)
Fall Quarter
Phase relationships and index properties, permeability, capillarity, effective stress concept, porous media flow, stress distribution, Mohr circle, stress path concept, stress-strain behavior, shear strength. Prep. Undergraduate course in Soil Mechanics.

CIV 3411 Soil Mechanics II (2QH)
Winter Quarter
Continuation of CIV 3410. Consolidation theory, 1-D and 3-D settlement analysis, shear strength properties of soils, stress path analysis. Prep. CIV 3410.

CIV 3412 Stability and Seepage (2QH)
Spring Quarter
A continuation of CIV 3411. Stability of open cuts and natural slopes; numerical analysis and computer applications to stability, seepage, consolidation, and deformation problems, laboratory testing; field instrumentation; special topics. Prep. CIV 3411.

CIV 3420 Foundation Engineering I (2QH)
Fall Quarter
Review of soil mechanics principles; bearing capacit y and settlement of conventional shallow foundations and combined footings; lateral earth pressure theory; retaining wall design. Prep. CIV 3411.

CIV 3421 Foundation Engineering II (2QH)
Winter Quarter
Theory and design of components for braced excavations; sheet pile wall design; anchored bulkheads; slurry trench walls; bearing capacity and settlement of deep foundations (caissons, piles, pile groups); piles loaded laterally and in tension; pile driving formulas; negative skin friction. Prep. CIV 3420.

CIV 3422 Foundation Engineering III (2QH)
Spring Quarter, Alternate Years
Pile foundations, caissons, selection of foundation scheme; case studies. Prep. CIV 3421.

CIV 3450 Engineering Geology (2QH)
Winter Quarter, Alternate Years
Selected topics in historical and structural geology related to engineering geology; origin and occurrence of various rock types, geologic structures, faulting and joint systems; weathering of rock and weathering products, glaciation, geologic mapping and environmental aspects; case studies. Prep. Undergraduate course in geology.

CIV 3460 Landfill Design (2QH)
Winter Quarter
Introduction to landfill liner and cover system design, construction, performance, and regulation. Topics will include: liner/cover system elements and selection; introduction to geosynthetics; designing with geosynthetics for stability, filtration, permeability, and containment; leachate and leakage management; compacted clay barrier construction and specification; quality assurance/quality control (QA/QC) during design and construction; and review of Massachusetts solid waste regulations for MSW facilities. Prep. Undergraduate course in Soil Mechanics.

CIV 3470 Introduction to Dynamics and Earthquake Engineering(2QH)
Fall Quarter
Dynamic response analysis of one-degree-of-freedom systems, characteristics of earthquakes and resulting ground motions, response spectra, stress-strain behavior of soils during dynamic and repeated loading, laboratory and field determinations, wave propagation through elastic media, effect of local soil condition upon earthquake ground motions.

CIV 3471 Soil Dynamics (2QH)
Winter Quarter, Alternate Years
Dynamic response analysis of a single mass, multi-degree-of-freedom systems; machine foundation design and analysis; soil-structure interaction, ground vibrations, sources and control; shear strength during repeated loading, liquefaction; dynamic analysis of retaining structures and slopes. Prep. CIV 3470.

CIV 3480 Seismic Design (2QH)
Spring Quarter, Alternate Years
Earthquake considerations in building design process, dynamic analysis of multi-degree-of-

freedom elastic systems subjected to earthquake motions and cyclically applied forces, inelastic dynamic response analysis. Seismic provisions of building codes; soil-structure interaction. Prep. CIV 3470 and CIV 3546.

CIV 3485 Earthquake Engineering (2QH)
Spring Quarter, Alternate Years
Seismic hazard and seismic risk analysis; seismic design decision analysis; lifeline earthquake engineering; pipelines, liquid storage tanks, water distribution systems; earthquake analysis of earth dams and slopes; dynamic analysis of retaining walls and offshore facilities; dynamically loaded piles. Prep. CIV 3470.

CIV 3510 Structural Mechanics I (2QH)
Fall Quarter
Analysis of force equilibrium (stress), deformation/deplacement (strain), and force/deformation (Hooke's Law) for an elastic solid; compatibility; governing equations for complete and approximate elasticity solution. Plane stress solution for narrow rectangular beams. Torsion, Saint Venant's theory, membrane analogy, rectangular sections, thin open and closed sections. Introduction to bending of thin plates. Prep. Undergraduate structural mechanics and structural analysis.

CIV 3511 Structural Mechanics II (2QH)
Winter Quarter, Alternate Years
Consistent models for the mechanics of simple structural elements: axial, bending, plane stress, and the like. Equilibrium, geometry of deformation, and force/deformation as the governing relations of all structural elements. Work and energy principles: virtual displacement, virtual forces, minimum potential energy, minimum complementary energy, introduction to variational ideas,
Rayleigh-Ritz method. Prep. CIV 3510.

CIV 3520 Concrete Materials: Science and Technology (2QH)
Winter Quarter
Concrete components and microstructure including: chemical, physical, and micro-structural properties of cement hydration; role of water, effect of water quality and sulfate attack; aggregate type and properties, possible problems with aggregates (including alkali-aggregate reaction). Behavior of hardened concrete including: factors affecting concrete strength; effects of temperature, creep and shrinkage; nonstructural cracking, curing of hardened concrete; corrosion of steel in concrete, durability. Special Portland and non-Portland cements, admixtures, special concretes. Prep. Undergraduate Civil Engineering Materials.

CIV 3530 Finite Element Analysis of Structures (2QH)
As Announced
Introduction to finite-element method for structural analysis. Overview of direct stiffness method. Formulation of element stiffness matrices by direct use of elasticity relations and by energy methods for simple elements; axial, bending, plane stress, and plane strain; transformation of coordinate systems; lumping work equivalent loads; bounds on the error solution. Plate bending. Use of finite-element computer programs. Prep. CIV 3511.

CIV 3536 Structural Analysis (2QH)
Winter Quarter
Formulation and solution of structural problems with primary application to member systems (trusses, frames, curved members), matrix formulation of flexibility and stiffness methods: geometrically nonlinear behavior. Prep. Admission to the Graduate School of Engineering.

CIV 3546 Structural Dynamics (2QH)
Winter Quarter, Alternate Years
Matrix formulation of the dynamic equations of equilibrium. Generation of mass, stiffness and damping matrices, static condensation. Modal analysis of linear response. The response spectrum method in modal analysis. Discussion of numerical integration techniques for nonlinear analysis of multi-degree of freedom systems. Prep. CIV 3470 and CIV 3536.

CIV 3559 Behavior of Reinforced Concrete Structures (2QH)
Fall Quarter, Alternate Years
Moment-Curvature relationships for reinforced concrete cross sections; effect of design parameters in resulting behavior, ductility. Effective stiffness. Prep. Admission to Graduate School.

CIV 3560 Prestressed Concrete (2QH)
Spring Quarter, Alternate Years
Fundamentals of prestressing; design of prestressed concrete beams for flexure and shear; design of end blocks; load balancing method for the analysis of indeterminate prestressed structures; column design. Prep. Undergraduate Reinforced Concrete Design and Structural Analysis.

CIV 3561 Reinforced Concrete Slabs (2QH)
Spring Quarter, Alternate Years
Design of two-way slabs by the equivalent frame method; yield line theory; prestressing of slabs; the strip method; and introduction to folded plate design. Prep. Undergraduate Reinforced Concrete Design and Structural Analysis.

CIV 3570 Steel Design (2QH)
Fall Quarter
An advanced course in elastic design in structural steel. Design problems involving braced and rigid frame structures subject to gravity, wind and
seismic loads are considered. Prep. Undergraduate Steel Design and Structural Analysis.

CIV 3575 Bridge Design (2QH)
Spring Quarter, Alternate Years
Behavior of different types of bridge decks, design of typical cases using current AASHTO specifications. Development of mathematical models for computerized analysis of special cases; curved bridge design, skewed decks, etc. Prep. graduate standing (with undergraduate background in steel and concrete design).

CIV 3610 Urban Public Transportation (2QH)
Winter Quarter, Alternate Years
Analysis and planning of public transportation systems, including bus, subway, commuter rail, and paratransit. Performance models; service evaluation and monitoring; data collection; service design; demand prediction; institutional and economic issues. Prep. CIV 3131.

CIV 3630 Traffic Engineering (2QH)
Spring Quarter, Alternate Years
Measurement of traffic characteristics; theory of traffic flow and analytical techniques; highway capacity, performance evaluation, and intersection design including geometric and signalization options and introduction to computer methods. Prep. CIV 3131.

CIV 3635 Transportation Engineering (2QH)
Winter Quarter, Alternate Years
Description and evaluation of different modes of transportation existing and proposed; their performance and cost characteristics; design, performance, and selection criteria for vehicles and roadbeds. Prep. Admission to Graduate School.

CIV 3640 Theory and Practice of Transportation Planning I (2QH)
Fall Quarter, Alternate Years
Establishments of goals, objectives and criteria; the current planning framework; basic demand and supply analysis methods; transportation systems management; introductory environmental and economic evaluation. Prep. Admission to Graduate School.

CIV 3641 Theory and Practice of Transportation Planning II (2QH)
Fall Quarter, Alternate Years
Continuation of CIV 3640. Transportation demand modeling from regional economic analysis to traffic and public transportation network assignment; technical and economic evaluation; current issues, including environmental assessment. Prep. CIV 3640 to be taken previously or concurrently.

CIV 3650 Urban Transportation Analysis I (2QH)
Spring Quarter, Alternate Years
Travel demand models, including distribution, mode split, elasticity, and direct demand models; economic and performance evaluation under variable demand. Prep. CIV 3141 .

CIV 3651 Urban Transportation Analysis II (2QH)
Spring Quarter, Alternate Years
Deterministic and probabilistic performance models for a variety of transportation modes, with an emphasis on highways; design models for traffic control; and network equilibrium models. Prep. CIV 3161, CIV 3162, and CIV 3131.

CIV 3798 Masters Continuation (0QH)
Any Quarter

CIV 3799 PhD Continuation (0QH)
Any Quarter

CIV 3830 Special Topic in Civil Engineering (2QH)
Fall, Winter, Spring Quarters
This course is offered when the need for a special topic is evident to faculty and students. The course is initiated by the appropriate faculty members and discipline committee and approved by the department. Prep. Consent of the instructor.

CIV 3835 Special Project in Civil Engineering (2QH)
Any Quarter
An individual effort in an area selected by student and advisor and approved by the Departmental Discipline Committee resulting in a definitive report. Prep. Permission of the Department.

CIV 3850 Master's Report (4QH)
Any Quarter
An individual effort consisting of laboratory and/or literature investigation and analysis or advanced design of a project in an area of civil engineering selected by student and advisor resulting in a definitive report. The report must be completed 7 years from the start of the Master's program. Prep. Permission of the Civil Engineering Department.

CIV 3851 Master's Report (2QH)
Any Quarter

CIV 3860 Master's Thesis (8QH)
Any Quarter
Analytical and/or experimental research conducted by arrangement with and under the supervision of the department. Prep. Permission of the Civil Engineering Department.

CIV 3861 Master's Thesis (4QH)
Any Quarter

CIV 3862 Master's Thesis (2QH)
Any Quarter

CIV 3880 PhD Thesis (0QH)
Any Quarter
Open to full-time Doctoral students only. Prep. Admission to doctoral program in Civil Engineering.

COMPUTER SYSTEMS ENGINEERING

The Graduate School of Engineering offers an interdisciplinary program leading to the degree of Master of Science in Computer Systems Engineering. This program has courses drawn from the Departments of Electrical and Computer Engineering, Industrial Engineering and Information Systems, Mechanical Engineering and the College of Computer Science.

The program may be pursued on a full-time, part-time or cooperative plan basis. Students may select courses from both the day and evening offerings. Students must select one of the following three areas of concentration within the program:

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM)
Robotics
Engineering Software Design

Admitted students will be assigned a faculty advisor depending upon the area of concentration selected.

Master of Science Degree Requirements

A minimum of forty-eight quarter hours of graduate courses with a minimum grade point average of 3.00 is required to receive the degree. Refer to the regulations of the Graduate School of Engineering for detailed information on academic and administrative policies.

Students holding an engineering degree from an ABET accredited institution will qualify to apply for the Master of Science in Computer Systems Engineering. Students with a Bachelor of Science in the physical sciences may also apply. A Graduate Record Examination (GRE) may be required.

Prerequisite Courses

Students are expected to be proficient in a high-level structured programming language such as Pascal. Other prerequisites may be required of students in each concentration area. The following prerequisites are required, and up to 4 quarter hours of these courses may be applied to the 48 quarter hour minimum degree requirement. Determination of prerequisite needs will be made at the time of admission.

Prerequisite	Required by
High-level structure language	All concentrations
IIS 3604 Data Structures	All concentrations
IIS 3110 Pascal or COM 1100 Pascal and COM 3114 C Lab	Engineering Software Design
COM 1102 LISP COM 3114 C/UNIX	Robotics CAD/CAM majors

Course Descriptions

See the respective department section of this catalog for course descriptions.

Course Requirements

Each area of concentration requires a total of 48 quarter hours of course work consisting of the required courses plus electives drawn from the approved elective lists. Other courses may be used as electives if approved by petition. Students should petition through their advisor.

Robotics

Required Core Courses

IIS	3630	Machine Intelligence	4
ECE	3221	Linear Systems Analysis	4
ECE	3381	Classical Control Theory	4
ECE	3463	Robot Vision and Sensors	4
ECE	3472	Special Topics in Robotics	4
ECE	3540	Digital Control Systems	4
ECE	3466	Robotics and Automation Systems	4
	or		
ME	3468	Robot Mechanics and Control	4
ME	3500	Computer-Aided Graphics and Design	4

Subject Area Elective Courses

Students may elect any courses from the required list of the other two majors in Computer Systems Engineering. In addition, the following courses may be taken as electives: (Most of the courses listed below have two two-quarter hour equivalents; see the ECE course description section).

ECE	3211	Math Methods in Electrical Engineering I	4
ECE	3241	Applied Probability and Stochastic Processes	4
ECE	3321	Digital Signal Processing	4
ECE	3325	Numerical Methods and Computer Applications I	4
ECE	3331	Analog Integrated Circuits	4
ECE	3351	Digital Communications	4
ECE	3361	Detection and Estimation Theory	4
ECE	3371	Linear Optimal Control Theory	4
ECE	3391	Digital Computer Architecture	4
ECE	3395	VLSI Design	4
ECE	3398	VLSI Architectures	4
ECE	3469	Fault-Tolerant Computers	4
ECE	3503	Two-Dimensional Digital Signal Processing	4
ECE	3505	Digital Image Processing	4
ECE	3508	Modern Spectral Analysis	4
ECE	3511	Data Communication Networks	4
ECE	3514	Error Correcting Codes	4

ECE	3519	Information Theory	4
ECE	3522	Array Signal Processing	4
ECE	3523	Communication Systems	4
ECE	3526	Nonlinear Systems I	4
ECE	3529	Nonlinear Systems II	2
ECE	3531	Adaptive Signal Processing	4
ECE	3534	Digital Processing of Speech Signals	4
ECE	3546	Advanced Topics in Stochastic and Nonlinear Systems	4
ECE	3549	Multivariable Control Systems	4

CAD/CAM

Required Core Courses

IIS	3604	Data Structures	4
IIS	3628	Database Management Systems	4
or			
COM	3315	Database Systems	4
ME	3468	Robot Mechanics and Control	4
ME	3500	Computer-Aided Graphics and Design	4
ME	3510	Manufacturing, Design and Computers	4

Subject Area Elective Courses

Students may elect any courses from the required list of the other two majors in Computer Systems Engineering. Full-time students are encouraged to complete a thesis for twelve quarter hours of credit. In addition, the following courses may be taken as electives:

Design

ME	3100	Mathematical Methods for Mechanical Engineering	4
ME	3120	Theory of Elasticity	4
ME	3140	Advanced Dynamics	4
ME	3410	Numerical Methods in Mechanical Engineering	4
ME	3440	Advanced Mechanics of Materials	4
ME	3470	Vibration Theory and Applications	4
ME	3480	The Finite Element Method	4
ME	3520	Experimental Techniques in Design	4

Manufacturing

ECE	3451	Combinatorial Methods and Optimization Techniques	4
ECE	3463	Robot Vision and Sensors	4
ECE	3466	Robotics and Automation Systems	4
ECE	3472	Special Topics in Robotics	4
IIS	3113	Basic Probability and Statistics	4
IIS	3217	Engineering Project Management	4

IIS	3310	Manufacturing Methods and Processes	4
IIS	3311	Computer-Aided Manufacturing	4
IIS	3400	Human Factors Engineering	4
IIS	3503	Simulation Methodology and Applications	4
IIS	3530	Operations Research I	4
IIS	3516	Statistical Quality Control	4
IIS	3540	Total Quality Control for Engineering	4
ME	3525	Manufacturing Methods for Engineers	4

Intelligent CAD/CAM

CHE	3510	Modeling and Simulation of Chemical Processes	4
COM	3112	LISP	4
COM	3315	Database Systems	4
COM	3360	Object-Oriented Systems	4
COM	3410	Foundations of Artificial Intelligence	4
COM	3411	Methods of Artificial Intelligence	4
COM	3420	Knowledge Representation	4
COM	3430	Expert Systems	4
COM	3440	Natural Language Processing	4
COM	3480	Connectionist Models of Learning	4
COM	3499	Topics in Artificial Intelligence	4
ECE	3221	Linear Systems Analysis	4
IIS	3624	Software Engineering	4
IIS	3629	Expert Systems in Engineering	4
IIS	3630	Machine Intelligence	4
IIS	3631	Machine Learning	4
IIS	3637	Programming Languages for Software Engineering	4

Engineering Software Design

Required Core Courses

IIS	3217	Engineering Project Management	4
IIS	3607	Operating Systems & Systems Software	4
IIS	3610	Computer Architecture	4
IIS	3624	Software Engineering	4
IIS	3637	Programming Languages for Software Engineering	4
IIS	3652	Software Engineering Project I	4
	or		
IIS	3840	Engineering Software Design Thesis	8

Subject Area Elective Courses

Students may elect any courses from the required list of the other two majors in Computer Systems Engineering. In addition, the following courses may be taken as electives:

Software Engineering

IIS	3601	Compiler Design	4
IIS	3626	Networks and Telecommunications	4
IIS	3804	Special Topics	4

Knowledge-Based Systems

IIS	3629	Expert Systems in Engineering	4
IIS	3630	Machine Intelligence	4
IIS	3631	Machine Learning	4

Software for Engineering

CHE	3510	Modeling and Simulation of Chemical Processes	4
ECE	3221	Linear Systems Analysis	4
ECE	3463	Robot Vision and Sensors	4
ECE	3466	Robotics and Automations Systems	4
ECE	3472	Special Topics in Robotics	4
IIS	3309	Computer Methods in Manufacturing	4
IIS	3503	Simulation Methodology and Applications	4
IIS	3523	Applied Statistics	4
ME	3468	Robot Mechanics and Control	4
ME	3500	Computer-Aided Graphics and Design	4
ME	3510	Manufacturing, Design and Computers	4

The Doctor of Philosophy Degree

Students interested in pursuing their research goals related to Computer Systems Engineering beyond the Master of Science level may pursue the Doctor of Philosophy Degree under the Interdisciplinary PhD program described elsewhere in this catalog.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

The Department of Electrical and Computer Engineering offers graduate programs leading to the degrees of Master of Science in Electrical Engineering, Master of Science (no specification), Electrical Engineer, and Doctor of Philosophy in Electrical Engineering. The Master of Science degree program may be completed on either a part-time, a continuous full-time, or a cooperative full-time basis. The Electrical Engineer and the PhD degree programs must be completed on a basis consistent with the residence requirements for the degree. The curriculum offers areas of concentration in computer engineering; communications and signal processing; control systems and signal processing; power systems; electronic circuits and semiconductor devices; and electromagnetics, plasma and optics.

Students in the Industrial Fellowship or Women in Engineering Programs follow the same degree requirements in their subject areas required of all graduate students. Courses offered in the day typically carry four quarter hours of credit; their two-quarter-hour equivalents are given in the evening over two academic quarters.* Each full-time student is responsible for meeting with his or her faculty advisor early in the program so that an appropriate sequence of courses may be arranged. Part-time students should follow the prescribed requirements and confer with their faculty advisors as needed.

Master of Science Degree Requirements

A minimum of forty-four quarter hours of graduate courses with a minimum grade point average of 3.0 is required in all programs. Full-time students are required to complete either an eight quarter hour Master of Science thesis or a four quarter hour seminar as part of their program. Industrial Fellowship students must complete the eight quarter hour Master of Science thesis. Master of Science thesis or seminar is optional for part-time students. For students selecting the thesis option, an Examination Committee shall be formed consisting of the student's major advisor and two full-time faculty members (or one full-time faculty member and one advisor from industry) with background relevant to the thesis topic. The thesis shall be presented by the student to the Committee and to the ECE Department-at-large in the form of a seminar before final approval of the thesis is granted. Please refer to the regulations of the Graduate School of Engineering for detailed information on academic and administrative policies.

All graduate courses presuppose mastery of the subject matter of a modern ABET accredited curriculum in electrical engineering. Students with a Bachelor of Science degree in other engineering or related science fields and students with a BSEE degree who have not taken graduate academic work for some time may be required to take one or more of the following undergraduate level prerequisite courses to satisfy any deficiencies. These courses carry no credit toward the graduate degree.

* **NOTE**: to earn credit for a partA/part B course you must take both part A and part B

Prerequisite Courses

	Credits
ECE 3100 Introduction to Circuits and Systems	4
ECE 3101 Introduction to Electronics	4
ECE 3102 Introduction to Electromagnetic Field Theory	4
ECE 3103 Introduction to Digital Computers	4
ECE 3104 Introduction to Communications	4
ECE 3105 Introduction to System Software I	2
ECE 3106 Introduction to System Software II	2
ECE 3107 Introduction to System Software III	2
ECE 3108 Introduction to Signals and Systems	4
ECE 3120 Power Circuit Analysis I	2
ECE 3130 Electric Machinery Theory I	2

* **NOTE**: The above courses cannot be used toward the 44 quarter hour degree requirement

Computer Engineering

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	12 QH	12 QH	12 QH
Subject Area Elective Courses	16 QH	20 QH	24 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0 QH
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses)

	Credits
ECE 3211 (3212,3213) Math Methods in Electrical Engineering I	4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes	4

Subject Area Required Courses

ECE 3311 (3312,3313) Software Engineering I	4
ECE 3391 (3392,3393) Digital Computer Architecture	4
ECE 3395 (3396,3397) VLSI Design	4

Subject Area Elective Courses

ECE 3200 Mathematical Methods in Computer Science	2
ECE 3221 (3222,3223)Linear Systems Analysis	4
ECE 3231 (3232,3233) Math Methods in Electrical Engineering II	4
ECE 3314 Software Engineering II	2
ECE 3321 (3322,3323) Digital Signal Processing	4

ECE 3325 (3326,3327) Numerical Methods & Computer Applic. I....4
ECE 3328 Numerical Meth & Computer Applications II....2
ECE 3331 (3332,3333) Analog Integrated Circuits....4
ECE 3341 (3342,3343) Electromagnetic Theory I....4
ECE 3351 (3352,3353) Digital Communications....4
ECE 3361 (3362,3363) Detection and Estimation Theory....4
ECE 3371 (3372,3373) Linear Optimal Control Theory....4
ECE 3381 (3382,3383) Classical Control Theory....4
ECE 3394 Microprogramming....2
ECE 3398 (3399,3400) VLSI Architectures....4
ECE 3401 (3402,3403) Digital System Des. with Hdwre. Desc. Lang....4
ECE 3440 (3441,3442) Microprocessor - System Design....4
ECE 3443 (3444,3445) Theory of Computation....4
ECE 3447 (3448,3449) Switching Theory I....4
ECE 3450 Switching Theory II....2
ECE 3451 (3452,3453) Combinatorial Methods & Optimization Tech....4
ECE 3454 Graph Theory....2
ECE 3460 Special Topics in Computer Engineering....2
ECE 3463 (3464,3465) Robot Vision & Sensors....4
ECE 3466 (3467,3468) Robotics & Automation Systems....4
ECE 3469 (3470,3471) Fault-Tolerant Computers....4
ECE 3472 Special Topics in Robotics....4
ECE 3473 Parallel Architectures for Signal Processing....4
ECE 3476 Special Topics in Fault-Tolerant Computing....4
ECE 3477 Testing and Design for Testability....4
ECE 3497 (3498,3499) Statistical Signal Processing....4
ECE 3480 Distributed Systems....4
ECE 3483 Multiprocessor Architectures....4
ECE 3502 Special Topics in DSP - Fast Algorithms....2
ECE 3503 Two-Dimensional Digital Signal Processing....2
ECE 3505 (3506,3507) Digital Image Processing....4
ECE 3508 (3509,3510) Modern Spectral Analysis....4
ECE 3511 (3512,3513) Data Communications Networks....4
ECE 3514 (3515,3516) Error Correcting Codes....4
ECE 3521 Multidimensional Spectrum Estimation....2
ECE 3522 Array Signal Processing....2
ECE 3531 (3532,3533) Adaptive Signal Processing....4
ECE 3534 (3535,3536) Digital Processing of Speech Signals....4
ECE 3549 (3550,3551) Multivariable Control Systems....4
ECE 3555 Statistical Pattern Recognition and Neural Networks....4
ECE 3589 Optical Storage and Display....2
ECE 3623 (3624,3625) Gate Array Design....4
ECE 3626 (3627,3628) Integrated Circuits Fabrications Proc. I....4
ECE 3629 (3630,3631) Integrated Circuits Fabrications Proc. II....4
ECE 3632 (3633,3637) Design & Analysis of Digital Integ. Circ. II....4
ECE 3893 Special Problems in Electrical Engineering....2 or 4
COM3205 Software Design and Development....4
COM3450 Syntactic Pattern Recognition....4
COM3640 Parallel Computation....4
COM3336 Operating Systems I....4
or IIS 3607 Operating Systems & Systems Software....4
Master of Science Thesis ECE 3860....8
or Master of Science Seminar ECE 3887, 3888

Communications and Signal Processing

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses)

		Credits
ECE 3211 (3212,3213)	Math Methods in Electrical Engineering I	4
ECE 3241 (3242,3243)	Applied Probability & Stochastic Processes	4

Subject Area Required Courses

ECE 3221 (3222,3223)	Linear Systems Analysis	4
ECE 3321 (3322,3323)	Digital Signal Processing	4
ECE 3351 (3352,3353)	Digital Communications	4
ECE 3361 (3362,3363)	Detection and Estimation Theory	4

Subject Area Elective Courses

ECE 3231 (3232,3233)	Math Methods in Electrical Engineering II	4
ECE 3325 (3326,3327)	Numerical Methods and Computer Applications I	4
ECE 3331 (3332,3333)	Analog Integrated Circuits	4
ECE 3341 (3342,3343)	Electromagnetic Theory I	4
ECE 3344 (3345,3346)	Electromagnetic Theory II	4
ECE 3371 (3372,3373)	Linear Optimal Control Theory	4
ECE 3381 (3382,3383)	Classical Control Theory	4
ECE 3391 (3392,3393)	Digital Computer Architecture	4
ECE 3395 (3396,3397)	VLSI Design	4
ECE 3398 (3399,3400)	VLSI Architectures	4
ECE 3451 (3452,3453)	Combinatorial Methods & Optimization Tech	4
ECE 3473	Parallel Architectures for Signal Processing	4
ECE 3497 (3498,3499)	Statistical Signal Processing	4
ECE 3500	Auditory Signal Processing	4
ECE 3502	Special Topics in DSP: Fast Algorithms	2
ECE 3503	Two-Dimensional Digital Signal Processing	2
ECE 3505 (3506,3507)	Digital Image Processing	4
ECE 3508 (3509,3510)	Modern Spectral Analysis	4
ECE 3511 (3512,3513)	Data Communications Networks	4
ECE 3514 (3515,3516)	Error Correcting Codes	4
ECE 3519 (3517,3518)	Information Theory	4
ECE 3520	Special Topics in Communication Theory	2
ECE 3521	Multidimensional Spectrum Estimation	2
ECE 3522	Array Signal Processing	2
ECE 3523 (3524,3525)	Communication Systems	4
ECE 3526 (3527,3528)	Nonlinear Systems I	4

ECE 3529 Nonlinear Systems II.....2
ECE 3530 Three Dimensional Picture Processing..... 2
ECE 3531 (3532,3533) Adaptive Signal Processing.....4
ECE 3534 (3535,3536) Digital Processing of Speech Signals..... 4
ECE 3537 (3538,3539) Multi-User Communications Systems.....4
ECE 3540 (3541,3542) Digital Control System..... 4
ECE 3543 (3544,3545) Stochastic Control Theory.....4
ECE 3546 (3547,3548) Adv. Topics in Stochastic & Nonlinear Sys.....4
ECE 3549 (3550,3551) Multivariable Control Systems.....4
ECE 3552 System Identification and Adaptive Control..... 4
ECE 3555 Statistical Pattern Recognition and Neural Networks..... 4
ECE 3556 Special Topics in System Theory..... 4
ECE 3557 Special Topics in Signal Processing.....4
ECE 3560,3561,3562 Acoustics I, II, III.....2 each
ECE 3563 (3564,3565) Radar Systems I.....4
ECE 3566 Radar Systems II.....2
ECE 3567 Network Information Theory.....4
ECE 3571 (3572,3573) Fourier Optics I..... 4
ECE 3574 Fourier Optics II..... 2
ECE 3579 Optoelectronics and Fiber Optics..... 2
ECE 3582 (3580,3581) Electro-Optics.....4
ECE 3598 Remote Sensing.....4
ECE 3635 (3636,3637) Antennas and Radiation.....4
ECE 3893 Special Problems in Electrical Engineering.....2 or 4
Master of Science Thesis ECE 3860..... 8
or Master of Science Seminar ECE 3887,3888..... 2 each

Control Systems and Signal Processing

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses)

			Credits
ECE	3211	(3212,3213) Math Methods in Electrical Engineering I	4
ECE	3241	(3242,3243) Applied Probability & Stochastic Processes	4

Subject Area Required Courses

ECE	3221	(3222,3223) Linear Systems Analysis	4
ECE	3321	(3322,3323) Digital Signal Processing	4
ECE	3371	(3372,3373) Linear Optimal Control Theory	4
ECE	3381	(3382,3383) Classical Control Theory	4

Subject Area Elective Courses

ECE	3231	(3232,3233) Math Methods in Electrical Engineering II	4
ECE	3325	(3326,3327) Numerical Methods and Computer Applications I	4
ECE	3331	(3332,3333) Analog Integrated Circuits	4
ECE	3341	(3342,3343) Electromagnetic Theory I	4
ECE	3351	(3352,3353) Digital Communications	4
ECE	3361	(3362,3363) Detection and Estimation Theory	4
ECE	3391	(3392,3393) Digital Computer Architecture	4
ECE	3395	(3396,3397) VLSI Design	4
ECE	3398	(3399,3400) VLSI Architectures	4
ECE	3440	(3441,3442) Microprocessor-Systems Design	4
ECE	3451	(3452,3453) Combinatorial Methods & Optimization Tech	4
ECE	3463	(3464,3465) Robot Vision & Sensors	4
ECE	3466	(3467,3468) Robotics & Automation System	4
ECE	3472	Special Topics in Robotics	4
ECE	3473	Parallel Architecture for Signal Processing	4
ECE	3480	Distributed Systems	4
ECE	3497	(3498,3499) Statistical Signal Processing	4
ECE	3500	Auditory Signal Processing	4
ECE	3502	Special Topics in DSP: Fast Algorithms	2

ECE 3503 Two-Dimensional Digital Signal Processing..... 2
ECE 3505 (3506,3507) Digital Image Processing..... 4
ECE 3508 (3509,3510) Modern Spectral Analysis..... 4
ECE 3511 (3512,3513) Data Communication Networks..... 4
ECE 3514 (3515,3516) Error Correcting Codes..... 4
ECE 3519 (3517,3518) Information Theory..... 4
ECE 3520 Special Topics in Communication Theory..... 2
ECE 3521 Multidimensional Spectrum Estimation..... 2
ECE 3522 Array Signal Processing..... 2
ECE 3523 (3524,3525) Communication Systems..... 4
ECE 3526 (3527,3528) Nonlinear Systems I..... 4
ECE 3529 Nonlinear Systems II..... 2
ECE 3530 Three-Dimensional Picture Processing..... 2
ECE 3531 (3532,3533) Adaptive Signal Processing..... 4
ECE 3534 (3535,3536) Digital Processing of Speech Signals..... 4
ECE 3540 (3541,3542) Digital Control Systems..... 4
ECE 3543 (3544,3545) Stochastic Control Theory..... 4
ECE 3546 (3547,3548) Adv. Topics in Stochastic & Nonlinear Sys..... 4
ECE 3549 (3550,3551) Multivariable Control Systems..... 4
ECE 3552 System Identification and Adaptive Control..... 4
ECE 3555 Statistical Pattern Recognition and Neural Networks..... 4
ECE 3556 Special Topics in System Theory..... 4
ECE 3557 Special Topics in Signal Processing..... 4
ECE 3560,3561,3562 Acoustics I, II, III..... 2 each
ECE 3563 (3564,3565) Radar Systems I..... 4
ECE 3566 Radar Systems II..... 2
ECE 3567 Network Information Theory..... 4
ECE 3574 Fourier Optics II..... 2
ME 3468 Robot Mechanics and Control..... 4
ECE 3893 Special Problems in Electrical Engineering..... 2 or 4
Master of Science Thesis ECE 3860..... 8
or Master of Science Seminar ECE 3887,3888..... 2 each

Electronic Circuits and Semiconductor Devices

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses)

	Credits
ECE 3211 (3212,3213) Math Methods in Electrical Engineering I	4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes	4

Subject Area Required Courses

ECE 3221 (3222,3223)Linear Systems Analysis	4
ECE 3331 (3332,3333) Analog Integrated Circuits	4
ECE 3384 (3385,3386) Char. & Models of Solid State Devices I	4
ECE 3395 (3396,3397) VLSI Design	4

Subject Area Elective Courses

ECE 3321 (3322,3323) Digital Signal Processing	4
ECE 3341 (3342,3343) Electromagnetic Theory I	4
ECE 3344 (3345,3346) Electromagnetic Theory II	4
ECE 3388 (3389,3390) Characteristics & Mod. of Solid State Dev. II	4
ECE 3391 (3392,3393) Digital Computer Architecture	4
ECE 3398 (3399,3400) VLSI Architectures	4
ECE 3401 (3402,3403) Digital System Design with Hdwre Descrp. Lang	4
ECE 3440 (3441,3442) Microprocessor - System Design	4
ECE 3523 (3524,3525) Communication Systems	4
ECE 3610 (3611,3612) Electronics of Analog Signal Processing	4
ECE 3613 (3614,3615) Solid State Microwave Circuits	4
ECE 3616 (3617,3618) Active Network Synthesis & Design	4
ECE 3619 (3620,3621) Network Synthesis	4
ECE 3622 Special Topics in Electronics - Analog MOS LSI	2
ECE 3623 (3624,3625) Gate Array Design	4
ECE 3626 (3627,3628) Integrated Circuits Fabrication Proc. I	4
ECE 3629 (3630,3631) Integrated Circuits Fabrication Proc. II	4
ECE 3632 (3633,3634) Design & Analysis of Digital Integrated Cir	4
ECE 3638 (3639,3640) Microwave Electron Devices	4
ECE 3641 Microwave Solid State Services	4
ECE 3644 Passive Microwave Circuits	4
ECE 3649 Semiconductor Device Modeling	4
ECE 3893 Special Problems in Electrical Engineering	2 or 4
Master of Science Thesis ECE 3860	8
or Master of Science Seminar ECE 3887,3888	2 each

Electromagnetics, Plasma and Optics

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Course	12 QH	12 QH	12 QH
Subject Area Elective Course.	16 QH	20 QH	24 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses) Credits

ECE 3241 (3242,3243) Applied Probability & Stochastic Processes....4
ECE 3231 (3232,3233) Math Methods in Electrical Engineering II....4

Subject Area Required Courses

ECE 3341 (3342,3343) Electromagnetic Theory I....4
ECE 3344 (3345,3346) Electromagnetic Theory II....4
ECE 3347 (3348,3349) Computational Methods in Electromagnetics....4

Subject Area Electives Courses

ECE 3211 (3212,3213) Math Methods in Electrical Engineering I....4
ECE 3221 (3222,3223) Linear Systems Analysis....4
ECE 3321 (3322,3323) Digital Signal Processing....4
ECE 3384 (3385,3386) Char. & Models of Solid State Devices I....4
ECE 3395 (3396,3397) VLSI Design....4
ECE 3523 (3524,3525) Communication Systems....4
ECE 3557 Special Topics in Signal Processing....4
ECE 3560,3561,3562 Acoustics I, II, III....2 each
ECE 3563 (3564,3565) Radar Systems I....4
ECE 3566 Radar Systems II....2
ECE 3571 (3572,3573) Fourier Optics I....4
ECE 3574 Fourier Optics II....2
ECE 3576,3577,3578 Lasers I, II, III....2 each
ECE 3579 Optoelectronics and Fiber Optics....2
ECE 3582 (3580,3581) Electro-Optics....4
ECE 3583,3584,3585 Optical Properties of Matter I, II, III....2 each
ECE 3586 (3587,3588) Principles of Optical Detection....4
ECE 3589 Optical Storage and Display....2
ECE 3590 Optical Instrumentation Design....2
ECE 3591 Spectroscopic Instrumentation....2
ECE 3593 Plasma Engineering....4
ECE 3594 (3595,3596) Plasma Theory....4
ECE 3597 Optical Properties of Matter....4
ECE 3598 Remote Sensing....4
ECE 3600 (3601,3602) Microwave Properties of Materials....4
ECE 3603 (3604,3605) Propagation in Artificial Structures....4
ECE 3606 (3607,3608) Applications of Plasma Engineering....4
ECE 3609 Special Topics in Electromagnetics....4
ECE 3613 (3614,3615) Solid State Microwave Circuits....4
ECE 3626 (3627,3628) Integrated Circuits Fabrication Proc. I....4
ECE 3629 (3630,3631) Integrated Circuits Fabrication Proc. II....4
ECE 3635 (3636,3637) Antennas and Radiation....4
ECE 3638 (3639,3640) Microwave Electron Devices....4
ECE 3641 Microwave Solid State Devices....4
ECE 3644 Passive Microwave Circuits....4
ECE 3893 Special Problems in Electrical Engineering....2 or 4
Master of Science Thesis ECE 3860....8
or Master of Science Seminar ECE 3887,3888....2 each

Power Systems

Course Requirements

	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required*	44 QH	44 QH	44 QH

*exclusive of any prerequisite courses

Required Core Courses (2 QH equivalents are in parentheses)

	Credits
ECE 3211 (3212,3213) Math Methods in Electrical Engineering I	4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes	4

Subject Area Required Courses

ECE 3221 (3222,3223) Linear Systems Analysis	4
ECE 3302,3303 Power Circuit Analysis II, III	2 each
ECE 3305 Computers in Power Systems I	2
ECE 3308 Electric Machinery Theory II	2
ECE 3341 (3342,3343) Electromagnetic Theory I	4

Subject Area Elective Courses

ECE 3304 Solid State DC Motor Drive Technology	2
ECE 3306 Computers in Power Systems II	2
ECE 3307 Solid State AC Motor Drive Technology	2
ECE 3309 Electric Machinery Theory III	2
ECE 3371 (3372,3373) Linear Optimal Control Theory	4
ECE 3381 (3382,3383) Classical Control Theory	4
ECE 3412 Power Systems Planning	4
ECE 3415 Power Systems Protection	2
ECE 3416 Power Systems Transients	2
ECE 3423 Special Topics in Power	2
ECE 3424 Power System Dynamics	2
ECE 3430,3431 Studies in Electric Power Transmission I, II	2 each
ECE 3893 Special Problems in Electrical Engineering	2 or 4
ME 3200 (3201,3202) General Thermodynamics	4
ME 3343 Power Generation Economics & Planning	2
ME 3386,3387,3388 Nuclear Engineering I, II, III	2 each
Master of Science Thesis ECE 3860	8
or Master of Science Seminar ECE 3887,3888	2 each

The Electrical Engineer Degree

The Department of Electrical and Computer Engineering offers the graduate professional degree usually known as the Engineer Degree. This degree usually requires about one year of full-time graduate study beyond the Master of Science degree and may also be pursued on a part-time basis. The official title of the degree is "Electrical Engineer."

Qualification, Degree Candidacy and Examinations

Admission to the Electrical Engineer Degree Program requires that the candidate have a BSEE or MSEE degree with a strong academic background. A student admitted to the Engineer Degree program will be designated as a candidate for this degree. In order to qualify for the degree, a student must maintain a 3.00 grade point average and receive no "F" grades. In some instances, a student may be required to take special examinations. Such examinations will be determined in each case by the departmental graduate committee.

Course Requirements

The minimum course requirements are 40 quarter hours beyond the Master of Science degree. No more than 10 out of the 40 quarter hours of credit are allowed for thesis and special problems combined. A minimum of 20 quarter hours must be taken in regularly scheduled electrical engineering subjects. All candidates must register for a minimum of four quarter hours of course work each quarter as approved by their academic advisors. Registration must be continuous unless withdrawal is approved by the department graduate committee.

Approval for transfer of credit may be given by the departmental graduate committee upon written request from the student. Such requests should be submitted at the time of application to the program. A maximum of 10 quarter hours of credit may be transferred from another school but transfer credits for thesis are not allowed.

After admission to the program, a maximum of 5 years will be allowed for completion of the degree requirements. Extension of this time limit may be granted by the departmental graduate committee.

Language Requirement

No foreign language is required for the Electrical Engineer degree.

Residence Requirement

The residence requirement is satisfied by two academic quarters of full-time graduate work during the same academic year or part-time graduate work during a period of two consecutive academic years subject to approval of the advisor.

Thesis

Each Engineer Degree student must complete a thesis which demonstrates a high level of competence in research, development, or design in the field of electrical engineering. Thesis registration must total at least six quarter hours of graduate work. In no case will more than ten quarter hours be credited towards the degree requirements. In some cases a Master of Science thesis of superior quality may be used to satisfy the thesis requirement.

A Thesis Examination Committee shall be formed consisting of the student's major advisor and two full-time faculty members (or one full-time faculty member and one advisor from industry) with background relevant to the thesis topic. The thesis shall be presented to the Committee and to the ECE Department-at-large in the form of a seminar presentation before final approval of the thesis is granted.

The Doctor of Philosophy Degree

Qualifying Examination and Degree Candidacy

First, and foremost, the PhD Qualifying Examination is the entrance examination for the admission to the doctoral program. In addition, this examination has the dual purpose of 1: serving as an indicator of the student's capability for successful completion of the program, and 2: serving as a guide to his or her advisor in developing a suitable plan of study tailored to the individual needs of the candidate. A student who has received approval to take the qualifying examination is considered a pre-doctoral student until such time as he or she passes the examination. Upon successful completion of the qualifying examination he or she becomes a PhD candidate.

With these goals in mind, the candidate is urged to take the qualifying examination early in his or her graduate program (i.e., not later than the successful completion of 40 quarter hours of graduate work). The examination is composed of a written and an oral part and is usually given in the spring quarter of each academic year. For the written part, the student is required to choose *three* out of the following five areas of concentration:

1. Signals and Systems
2. Fields, Waves and Optics
3. Circuits and Electronics
4. Computer Engineering
5. Energy Conversion and Power Systems

One of the three areas should be that closest to the specialty area in which the student plans to do his or her doctoral thesis work.

The oral part is designed to test general comprehension. Together, the oral and written portions of the examination are designed to test the factual knowledge of a typical undergraduate Electrical Engineering program.

If the examination is failed it may be repeated only with permission of the Graduate Committee upon recommendation of the PhD Qualifying Examination Committee.

Course Requirements

Successful completion of a doctoral program normally requires a minimum of 70 quarter hours of satisfactory graduate level work beyond the Bachelor of Science degree, exclusive of doctoral seminar (required), doctoral reading, and doctoral dissertation.

The course work must include a three-course sequence (12 QH graduate level courses) in each of two minor areas. Both minors must be science, applied science, or a related area. One minor may be chosen from an area of electrical engineering outside the candidate's proposed major area.

Upon successful completion of the PhD qualifying examination and the majority of required coursework, the student is required to register in three consecutive quarters for ECE 3880 (Doctoral Thesis). Upon completion of this sequence, the student is required to register for

ECE 3799 (PhD Thesis Continuation) in every quarter until the dissertation has been completed. Students may not register for continuation until the three-quarter thesis sequence has been fulfilled.

Technical Writing Requirement

Successful completion of a graduate-level technical writing course is required for all PhD candidates.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work or two consecutive years of part-time graduate work. In the latter case, a detailed time schedule must be approved by the student's advisor in order to give evidence that at least half of the time is being devoted to the requirements of the graduate school.

Dissertation

The candidate's dissertation research is directed by a Dissertation Advisor, whom he or she shall select after establishing candidacy. A Dissertation Committee shall be formed consisting of the Advisor and two full-time faculty members with background relevant to the thesis topic. The Committee may also include a person from industry. The Dissertation Committee will approve the dissertation in final form.

Comprehensive Examination

Within three years of his or her establishment of degree candidacy, the student will be required to demonstrate by means of a comprehensive examination a subject matter knowledge satisfactory for the award of the degree.

The comprehensive examination is an oral examination open to the Department of Electrical and Computer Engineering faculty (assistant professor and above in rank) and administered by the student's Dissertation Committee. Departmental faculty will be informed of the examination via a departmental notice at least one week prior to the examination. Normally the examination will be given at the time the Dissertation Proposal is submitted to the Dissertation Committee for approval. As part of this examination the Dissertation Committee will review the student's doctoral program and his or her performance in graduate courses, as well as examine the student on subject matter related to graduate studies and dissertation area.

Final Oral Examination

The final oral examination will include the subject matter of the doctoral dissertation and significant developments in the field of the dissertation work. Other related fields may be included if recommended by the examining committee.

Faculty

John G. Proakis, Chairman

Professors

Chan, Chung, PhD, University of Iowa; plasmas, electromagnetics
Devaney, Anthony, PhD, University of Rochester; tomography, electromagnetic wave propagation, inverse scattering
Feldman, James, PhD, Carnegie-Mellon University; physical electronics, computers, energy systems processing, robotics
Grabel, Arvin, ScD, New York University; circuit theory, electronics
Hanania, Jack, PhD, Leeds (England); power systems, electromagnetics
Mulukulta, Sarma, PhD, University of Colorado; power systems, electrical machinery, electromagnetic theory and its applications to electrical machines
Prasad, Sheila, PhD, Harvard University; microwave solid state devices and circuits
Proakis, John, PhD, Harvard University; digital communications, adaptive filtering, estimation, and digital signal processing
Raemer, Harold, PhD, Northwestern University; electromagnetic theory, communications, radar system analysis, microwave theory, electromagnetic scattering, plasma theory
Rochefort, J. Spencer, MS, Massachusetts Institute of Technology; communications, electronics, space telemetry
Sandler, Sheldon, PhD, Harvard University; electromagnetics, antennas, pattern recogni tion, robotics
Schetzen, Martin, ScD, Massachusetts Institute of Technology; systems theory, control systems, theory of nonlinear systems
Serafim, Philip, ScD, Massachusetts Institute of Technology; electromagnetics, remote sensing
Silevitch, Michael, PhD, Northeastern University; plasma theory, applications of plasma theory to auroral phenomena
Vittoria, Carmine, PhD, Yale University; electromagnetics, magnetic materials, microwave circuits

Associate Professors

Buus, Soren, PhD, Northeastern University; psychoacoustics, signal processing, microprocessors
Ingle, Vinay, PhD, Rensselaer Polytechnic Institute; signal processing, image processing
Jacobson, Clas, PhD, Rensselaer Polytechnic Institute; control systems
Kellner, Wayne, ScD, Massachusetts Institute of Technology; circuit theory, graph theory, computer science
Lev-Ari, Hanoch, PhD, Stanford University; digital signal processing, adaptive filtering
Martin, Robert, MS, Northeastern University; circuit theory
McGruer, Nicol, PhD, Michigan State University; solid state devices, IC fabrication

McKnight, Stephen, PhD, University of Maryland; semiconductor devices and materials, electro-optics, electromagnetics
Merakos, Lazaros, PhD, University of Connecticut; communications, networks
Raghavan, Ram, PhD, University of Massachusetts; microwaves, remote sensing, electromagnetics
Rappaport, Carey, ScD, Massachusetts Institute of Technology; electromagnetics, micro waves
Shafai, Bahram, PhD, George Washington University; control systems, digital signal processing
Surya, Charles, PhD, University of Rochester; solid state devices, electronics
Vai, Man-Kuan, PhD, Michigan State; VLSI design, computer engineering
Zavracky, Paul, PhD, Tufts University; microsensor devices and device fabrication

Assistant Professors

Brady, David, PhD, Princeton University; digital communications, multi-user communications
Brooks, Dana, PhD, Northeastern University; digital signal processing
Crisman, Jill, PhD, Carnegie-Mellon University; robotics, robot vision
Czeck, Edward, PhD, Carnegie-Mellon University; computer engineering, fault-tolerant computing
Kay, Leonard, PhD, University of Massachusetts; solid-state devices, device modeling and characterization
Mannai, Dhamir, PhD, Pennsylvania State University; computer architecture, software engineering
Manolakos, Elias, PhD, University of Southern California; computer engineering, VLSI design, signal processing algorithms
McLaughlin, David, PhD, University of Massachusetts; radar systems, electromagnetics
Rangarajan, Sampath, PhD, Texas at Austin; parallel and distributed computing, fault-tolerant computing, VLSI
Salehi, Masoud, PhD, Stanford University; information theory, coding
Stankovic, Aleksander, PhD, Massachusetts Institute of Technology; power systems, power electronics, control systems
Tadmor, Gilead, PhD, Weizmann Institute, Israel; control systems

Advisors

An advisor will be assigned to you upon admission to the Graduate School. If you are unable to reach your advisor, you may call the Electrical and Computer Engineering Department office at (617) 373-5281.

ELECTRICAL AND COMPUTER ENGINEERING

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time.

ECE 3100 Introduction to Circuits and Systems (4QH)
Fall Quarter
The circuit elements (R, L and C) are introduced. Kirchoff's Laws, Tellegan and Thevenin's Theorem. Mesh and nodal analysis. Development of system function approach, Laplace and Fourier transform theory applied to circuit analysis. Sinusoidal steady-state, n-port network theory and power and energy concepts. Prep. Admission to Graduate School

ECE 3101 Introduction to Electronics (4QH)
Winter Quarter
Characteristics of the theoretical physical junction. The Ebers-Moll model for bipolar junction transistors, characteristics of bipolar and field-effect devices, basic digital inverters and logic gates and various logic families. Use of transistors in the design of analog circuits. Biasing, linearized incremental models, load lines, signal flowgraphs, frequency response and gain calculation for single and cascaded stages. Prep. ECE 3100 or equivalent.

ECE 3102 Introduction to Electromagnetic Field Theory (4QH)
Spring Quarter
Definition of scalar and vector fields; vector calculus; concepts of gradient, divergence, curl and the "del" operator; free-space electrostatics; the generalization of the Maxwell equations to the case of time-varying fields; Faraday induction law, wave equations and the place wave solution. Prep. ECE 3100 or equivalent.

ECE 3103 Introduction to Digital Computers (4QH)
Fall Quarter
Basic components of digital systems and methods for their analysis and design,combinational and sequential circuits, integrated circuit logic families and functional building blocks, registers, counters, decoders, multiplexers and memories. Data representation and coding techniques. Central processor alternatives; instruction formats, addressing modes, bus structures, arithmetic units, timing analysis and stacks. Algorithms for arithmetic operations with various data representations. Prep. Admission to Graduate School

ECE 3104 Introduction to Communications (4QH)
Spring Quarter
Review of system theory, convolution, Fourier series, Fourier integral, signal analysis, Fourier methods, correlation functions, density functions, power spectra, amplitude modulation, frequency modulation, phase modulation, sampling theory and digital modulation techniques. Prep. ECE 3108 or equivalent.

ECE 3105 Introduction to System Software I (2QH)
Fall Quarter
A knowledge of Pascal is helpful but not required. Programming style considerations software testing software reliability. Data structures, including stacks, queues, linked lists, trees and graphs. Emphasis on the use of Pascal to implement typical system software routines that use the above data structures. Miscellaneous topics also discussed are modern system software considerations for multiprocessor, array processor and graphic processor systems. Prep. Admission to Graduate School.

ECE 3106 Introduction to System Software II (2QH)
Winter Quarter
An analysis of absolute and relocatable program translators. Topics covered are assemblers, disassemblers, macroassemblers, linkers, an over-

view of compilers, interpreters, simulators and emulators. For a typical lab assignment, the student will design and implement an absolute assembler for a very simplified instruction set. Prep. ECE 3105.

ECE 3107 Introduction to System Software III (2QH)
Spring Quarter
An analysis of operating system structure and concepts. Memory management, fragmentation, paging, virtual memory, job and process scheduling, I/O management, file management. Operating system concepts for multi-user systems. Critical variables, race conditions, Dekkeer's algorithm, some sample multi-user routines. For a typical lab assignment, the student will write simulated paged memory management and process scheduling routines. Prep. ECE 3106

ECE 3108 Introduction to Signals and Systems (4QH)
Winter Quarter
Description and analysis of continuous and discrete time signals and systems. Time domain analysis of linear, time-invariant (LTI) systems. Frequency domain analysis of signals and LTI systems. Laplace and z-transforms. State space descriptions of continuous and discrete time systems. Prep: ECE 3100 or equivalent.

ECE 3120 Power Circuit Analysis I (2QH)
Fall Quarter
Fundamental concepts of single-phase and polyphase power systems; definitions of terms; use of per unit quantities; equivalent circuits of symmetrical 3-phase systems; introduction of symmetrical components; short circuits on systems with a single power source. Prep. BSEE or ECE 3100 & ECE 3102.

ECE 3130 Electrical Machinery Theory I (2QH)
Fall Quarter
Review of magnetic circuit concepts and electromechanical energy-conversion principles; steady-state analysis of transformers, synchronous machines, and induction machines. Prep. BSEE or ECE 3100 and ECE 3102.

ECE 3200 Mathematical Methods in Computer Science (2QH)
Fall Quarter
Algebraic concepts relevant to computer science; sets, relations, mapping, orderings, algebraic systems, Boolean algebras, groups, rings, finite fields, introduction to vector spaces and linear algebras over finite fields. Prep. Admission to Graduate School.

ECE 3211 Mathematical Methods in Electrical Engineering I (4QH)
Fall and Winter Quarters
Fundamental Algebraic Concepts; Sets, functions, relations, operations; Algebraic Structures; group, rings, fields, homomorphisms, polynomials; Vector Spaces and Linear Operators; representations, matrices and linear algebraic equations, orthogonality, equivalence and similarity transformations, eigenvalues and eigenvectors, canonical forms, functions of a square matrix, quadratic forms and congruence transformations, orthogonal transformations; Introduction to Polynomial Matrices; Applications to Communications and Control Theory. Prep. Admission to Graduate School

ECE 3212 Mathematical Methods in Electrical Engineering I-A (2QH)
Fall and Winter Quarters
ECE 3212 and ECE 3213 cover the same material with the same prerequisites as ECE 3211, but in two 2QH courses.

ECE 3213 Mathematical Methods in Electrical Engineering I-B (2QH)
Winter and Spring Quarters
Continuation of ECE 3212. Prep. ECE 3212.

ECE 3221 Linear Systems Analysis (4QH)
Winter and Spring Quarters
Introduction to the state variable theory of continuous and discrete linear systems. Standard canonical representations. The concept of state and the representation of interconnected systems. Linear spaces. The state equations and their solution. Stability. Introduction to the general control problem in terms of controllability and observability. Prep. ECE 3211, ECE 3108 or equivalent.

ECE 3222 Linear Systems Analysis A (2QH)
Fall and Winter Quarters
ECE 3222 and ECE 3223 cover the same material with the same prerequisites as ECE 3221, but in two 2QH courses.

ECE 3223 Linear Systems Analysis B (2QH)
Winter and Spring Quarters
Continuation of ECE 3222. Prep. ECE 3222.

ECE 3231 Mathematical Methods in Electrical Engineering II (4QH)
Fall Quarter
Complex variable theory; Analytic functions and Cauchy-Riemann equations, complex integration and Cauchy integral formula, Taylor and Laurent Series, the residue theorem, conformal mapping; Laplace transform and its applications, problems in partial differential equations; Generalized Fourier Series and Green's functions; General integral transforms; Sturm-Liouville, Fourier, Hankel, Legendre and other integral transforms. Prep. Admission to Graduate School.

ECE 3232 Mathematical Methods in Electrical Engineering II-A (2QH)
Fall Quarter
ECE 3232 and ECE 3233 cover the same material with the same prerequisites as ECE 3231, but in two 2QH courses.

ECE 3233 Mathematical Methods in Electrical Engineering II-B (2QH)
Winter Quarter
Continuation of ECE 3232. Prep. ECE 3232

ECE 3241 Applied Probability and Stochastic Processes (4QH)
Fall and Winter Quarters
Introductory probability, sample space and random variables, examples of discrete and continuous probability distribution functions, averages, moments and characteristic function, multivariate distributions, change of variables and functions of variables, central limit theorem, description of stochastic vectors. General concepts of stochastic processes, stationarity and ergodicity, stochastic continuity and differentiation, the Gaussian process, linear systems with stochastic inputs, correlation functions and power spectra, matched filtering, stochastic orthogonality and linear mean-square estimation filtering and prediction. Prep. ECE 3108 or equivalent.

ECE 3242 Applied Probability and Stochastic Processes A (2QH)
Fall and Winter Quarters
ECE 3242 and ECE 3243 cover the same material with the same prerequisites as ECE 3241, but in two 2QH courses.

ECE 3243 Applied Probability and Stochastic Processes B (2QH)
Winter and Spring Quarters
Continuation of ECE 3242. Prep. ECE 3242.

ECE 3302 Power Circuit Analysis II (2QH)
Winter Quarter
A continuation of ECE 3120 Power Circuit Analysis I. Sequence impedances of various power-system elements are considered from an application point of view; unsymmetrical faults on otherwise symmetrical 3-phase systems; open conductors and asymmetrical connections and loadings; analysis of simultaneous faults on 3-phase systems. Prep. ECE 3120.

ECE 3303 Power Circuit Analysis III (2QH)
Spring Quarter
A continuation of ECE 3302, Power Circuit Analysis II. Introduction of Clarke components and applications in analysis of asymmetrical systems and faults; application of Clarke components to the solution of surge phenomena problems; transmission line theory; fundamentals of systems stability. Prep. ECE 3302.

ECE 3304 Solid State DC Motor Control Systems (2QH)
Fall Quarter
DC motor dynamics and transfer function. Single phase and three phase rectifier circuits with motor loads. Feedback control, chopper controlled dc motors, examples from industry and design considerations. Prep. BSEE or ECE 3100 and ECE 3101, or equivalent.

ECE 3305 Computers in Power Systems I (2QH)
Fall Quarter
Techniques used in solving power system problems with the digital computer. Matrix formulations are examined, followed by a detailed treat-

ment of the short-circuit problem, including balanced and unbalanced faults. Various iterative techniques are studied for the solution of the power-flow problem. Prep. ECE 3120.

ECE 3306 Computers in Power Systems II (2QH)
Winter Quarter
Practical considerations of solving large scale networks. Network reductions, distribution factors and contingency analysis techniques. Digital models for regulated generators, fixed and load tap changing transformers and HVDC transmission lines. Computer methods for economic dispatch, loss coefficients and application of pumped hydro are developed. Prep. ECE 3305.

ECE 3307 Solid State AC Motor Drive Technology (2QH)
Winter Quarter
Induction and synchronous motor equivalent circuits and characteristics - operation of inverters - pulse-width modulation, voltage-source inverters, current-source inverters, load-commutated inverters and cycloconverters - feedback control - applications and design considerations.

ECE 3308 Electrical Machinery Theory II (2QH)
Winter Quarter
Mathematical description of a synchronous machine; per-unit representation; steady-state theory and transient performance; flux distribution and saturation in synchronous machines. Prep. ECE 3130.

ECE 3309 Electrical Machinery Theory III (2QH)
Spring Quarter
Review of transient behavior of synchronous machines; stability studies and excitation systems; synchronous machine modeling; generator protection; trends in development of large generators. Prep. ECE 3308.

ECE 3311 Software Engineering I (4QH)
Fall Quarter
An introduction to basic concepts in software engineering principles is given. Techniques of structured software design and testing are discussed along with issues of program reliability and complexibility. Management techniques are touched upon and a case study of a typical large software problem is undertaken. Prep. ECE 3105, 3106, 3107 or equivalent, and a knowledge of a high level programming language.

ECE 3312 Software Engineering I-A (2QH)
Fall and Winter Quarters
ECE 3312 and ECE 3313 cover the same material with the same prerequisites as ECE 3311, but in two 2QH courses.

ECE 3313 Software Engineering I-B (2QH)
Winter and Spring Quarters
Continuation of ECE 3312. Prep. ECE 3312.

ECE 3314 Software Engineering II (2QH)
Spring Quarter
Focus turns away from the general issues of the first two courses in this sequence and towards a very specific issue, modular design of software. Issues of stepwise-refinement and top-down design are explored in depth and organizational/data-flow issues are considered. Prep. ECE 3311 or 3313.

ECE 3321 Digital Signal Processing (4QH)
Winter and Spring Quarters
Theory and practice of modern signal processing techniques. Characteristics of discrete signals and systems; sampling and A/D conversion; difference equations; convolution; the z-transform, the Fourier transform and the discrete Fourier transform; fast Fourier transform algorithms; chirp z-transform algorithm; digital filter realizations; design techniques for IIR and FIR digital filters; computer programs for filter design; quantization effects in digital signal processing. Prep. ECE 3221.

ECE 3322 Digital Signal Processing A (2QH)
Fall and Winter Quarters
ECE 3322 and ECE 3323 cover the same material with the same prerequisites as ECE 3321, but in two 2QH courses.

ECE 3323 Digital Signal Processing B (2QH)
Winter and Spring Quarters
Continuation of ECE 3322. Prep. ECE 3322.

ECE 3325 Numerical Methods and Computer Applications I (4QH)
Winter Quarter
Survey of numerical methods applied to engineering and scientific problems with emphasis on machine implementation and problem solving; roundoff and cumulative errors; roots of polynomials and nonlinear functions; systems of linear and nonlinear algebraic equations; orthogonal function, least square Chebyshev approximation of functions; interpolation; numeric quadrature; ordinary and partial differential equations. Prep. Admission to Graduate School and a working knowledge of FORTRAN.

ECE 3326 Numerical Methods and Computer Applications I-A (2QH)
Fall and Winter Quarters
ECE 3326 and ECE 3327 cover the same material with the same prerequisites as ECE 3325, but in two 2QH courses.

ECE 3327 Numerical Methods and Computer Applications I-B (2QH)
Winter and Spring Quarters
Continuation of ECE 3326. Prep. ECE 3326.

ECE 3328 Numerical Methods and Computer Applications II (2QH)
Spring Quarter
Spectral analysis, including fast Fourier transforms, Hilbert transforms, convolution, and correlation techniques. Optimization, including dynamic programming and steepest descent techniques. PERT and linear programming. Other selected topics. Prep. ECE 3325 or ECE 3327.

ECE 3331 Analog Integrated Circuits (4QH)
Fall Quarter
Active transistor circuits and systems are treated with emphasis on modern integrated circuit architectures. Bipolar and field-effect (NMOS and CMOS) implementations of analog circuits are presented. Characteristics and behaviors of analog I.C. structures are explored through the study of circuits such as, operational amplifiers, instrumentation amplifiers, voltage comparators, various types of filter configuration and integrators as well as multipliers and logarithmic amplifiers. Features covered include linearity, dynamic range, slew-rate limiting and speed and gain bandwidth trade-offs. The role of feedback in stabilizing, linearizing and otherwise enhancing the performance of analog circuits is treated in detail. Noise limitations on circuit performance are explored. Noise models of devices and circuits are developed, leading to the prediction of system noise performance and techniques for optimizing signal-to-noise ratios. Prep. ECE 3101 or equivalent.

ECE 3332 Analog Integrated Circuits A (2QH)
Fall Quarter
ECE 3332 and ECE 3333 cover the same material with the same prerequisites as ECE 3331, but in two 2QH courses.

ECE 3333 Analog Integrated Circuits B (2QH)
Winter Quarter
Continuation of ECE 3332. Prep. ECE 3332

ECE 3341 Electromagnetic Theory I (4QH)
Fall Quarter
Emphasis is on the fundamental equations, their physical meaning, principal mathematical techniques and important engineering applications. Sources of the EM field. Lorentz force equation. Integral form of Maxwell's equations and point relations (differential equations and boundary conditions). Electromagnetic energy and power. Propagation of plane waves in homogeneous media. Reflection and transmission. Scalar and vector potentials. Solutions in the absence of boundaries for static and dynamic problems, with or without symmetry. Solutions to boundary value problems. Green's functions. Transmission lines, rectangular waveguides, and resonators. Dielectric slab guide. Prep. ECE 3102 or equiv.

ECE 3342 Electromagnetic Theory I-A (2QH)
Fall Quarter
ECE 3342 and ECE 3343 cover the same material with the same prerequisites as ECE 3341, but in two 2QH courses.

ECE 3343 Electromagnetic Theory I-B (2QH)
Winter Quarter
Continuation of ECE 3342. Prep. ECE 3342.

ECE 3344 Electromagnetic Theory II (4QH)
Winter Quarter
Examination of important electrodynamic applications by the use of advanced mathematical techniques. General theory of waveguides and resonators with application to the cylindrical geometry. Dielectric rod waveguide. Optical fibers. Radiation. Linear antennas. Loop antenna. Linear arrays. Ray optics. Scattering and diffraction of waves for planar, cylindrical and spherical geometries. Effects of random media. Prep. ECE 3341.

ECE 3345 Electromagnetic Theory II-A (2QH)
Winter Quarter
ECE 3345 and ECE 3346 cover the same material with the same prerequisites as ECE 3344, but in two 2QH courses.

ECE 3346 Electromagnetic Theory II-B (2QH)
Spring Quarter
Continuation of ECE 3345. Prep. ECE 3345.

ECE 3347 Computational Methods in Electromagnetics (4QH)
Winter Quarter
Solutions to problems in electromagnetics are presented using a wide variety of numerical and computational methods. Finite element methods are used to solve problems in electrostatics, diffusion, and wave propagation. Moment methods are used to solve the integral equations related to currents and charges on wire structures. Direct and inverse scattering is treated by approximate methods related to physical and geometrical optics. Computational methods are introduced in relation to the asymptotic evaluation of radiation integrals and in basically non-numerical approaches to solving the integral equations that occur in electromagnetics. Electromagnetic data handling, sampling, and processing is also treated. Prep. ECE 3341, 3344.

ECE 3348 Computational Methods in Electromagnetics A (2QH)
Fall Quarter
ECE 3348 and ECE 3349 cover the same material with the same prerequisites as ECE 3347, but in two 2QH courses.

ECE 3349 Computational Methods in Electromagnetics B (2QH)
Winter Quarter
Continuation of ECE 3348. Prep. ECE 3348.

ECE 3351 Digital Communications (4QH)
Winter Quarter
The theoretical and practical aspects of digital communications in the presence of channel distortion and additive noise. Topics covered include the basic binary and M-ary modulation techniques, namely, PSK, PAM, FSK, orthogonal and biorthogonal signals, and their performance in an additive Gaussian noise channel; signal waveforms constructed from binary block and convolutional codes; hard-decision decoding and soft-decision decoding of coded signal waveforms; performance of coded waveforms in an additive white Gaussian noise channel; trellis-coded modulation. Prep. ECE 3241 and ECE 3104 or equivalent.

ECE 3352 Digital Communications A (2QH)
Fall Quarter
ECE 3352 and ECE 3353 cover the same material with the same prerequisites as ECE 3351, but in two 2QH courses.

ECE 3353 Digital Communications B (2QH)
Winter Quarter
Continuation of ECE 3352. Prep. ECE 3352.

ECE 3361 Detection and Estimation Theory (4QH)
Winter Quarter
The classical theory of detection and estimation of signals in noise with emphasis on implementation of the theory. Particular topics include: hypothesis testing criteria; coherent detection of M-ary signals; diversity receiver; calculation of error probabilities. Detection in colored noise; parameter estimation using Bayes, maximum-likelihood, a maximum land posteriori criteria; applications of the theory to digital communications and radar. Prep. ECE 3241.

ECE 3362 Detection and Estimation Theory A (2QH)
Winter Quarter
ECE 3362 and ECE 3363 cover the same material with the same prerequisites as ECE 3361, but in two 2QH courses.

ECE 3363 Detection and Estimation Theory B (2QH)
Spring Quarter
Continuation of ECE 3362. Prep. ECE 3362.

ECE 3371 Linear Optimal Control Theory (4QH)
Spring Quarter
State-space, time-domain techniques for analyzing and designing linear optimal control systems will be explored. The goal is to introduce basic concepts of dynamic optimization and then to apply them to problems of short and long terms optimal control, stabilization, state estimation and filtering, stochastic and worst-case robust control. Emphasis will be placed on linear quadratic optimization. Prep: ECE 3221, ECE 3241.

ECE 3372 Linear Optimal Control Theory A (2QH)
Winter Quarter
ECE 3372 and ECE 3373 cover the same material with the same prerequisites as ECE 3371, but in two 2QH courses.

ECE 3373 Linear Optimal Control Theory B (2QH)
Spring Quarter
Continuation of ECE 3372. Prep. ECE 3372.

ECE 3381 Classical Control Theory (4QH)
Fall Quarter
Basic systems modeling; steady state and transient response analysis. Introduction to root-locus plots, Bode plots, Nyquist plots, and Nichols chart. The design of first order cascade and feedback compensators using the above plots. Pole-zero synthesis techniques and design techniques for the optimal linear regulator problem. Prep: ECE 3108 or equivalent.

ECE 3382 Classical Control Theory A (2QH)
Fall Quarter
ECE 3382 and ECE 3383 cover the same material with the same prerequisites as ECE 3381, but in two 2QH courses.

ECE 3383 Classical Control Theory B (2QH)
Winter Quarter
Continuation of ECE 3382. Prep. ECE 3382.

ECE 3384 Characteristics and Models of Solid State Devices I (4QH)
Fall Quarter
Designed to develop insight into the physics of semiconductors and the operation of semiconductor devices. Topics include: crystal structure, energy bands, carrier concentration at thermal equilibrium, semiconductor statistics, carrier transport phenomena, p-n junction theory, charge storage and diode transients, bipolar junction transistors, charge-control model, Gummel-Poon model. Prep: ECE 3101 or equivalent.

ECE 3385 Characteristics and Models of Solid State Devices I-A (2QH)
Fall Quarter
ECE 3385 and ECE 3386 cover the same material with the same prerequisites as ECE 3384, but in two 2QH courses. Prep: ECE 3101 or equivalent.

ECE 3386 Characteristics and Models of Solid State Devices I-B (2QH)
Winter Quarter
Continuation of ECE 3385. Prep. ECE 3385.

ECE 3388 Characteristics and Models of Solid State Devices II (4QH)
Winter Quarter
Metal-semiconductor contacts, methods of measurement of barrier height, MIS diode, C-V measurement to evaluate the interface-trapped charges; MOSFET device and structure, device scaling and second-order effects, CMOS structure; solid state microwave devices such as MESFET, MODFET, and the heterojunction bipolar transistor (HBT) will be discussed. An examination of noise in the microwave devices will be included. Prep. ECE 3384.

ECE 3389 Characteristics and Models of Solid State Devices II-A (2QH)
Winter Quarter
ECE 3389 and 3390 cover the same material with the same prerequisites as ECE 3388, but in two 2 QH courses. Prep. ECE 3384.

ECE 3390 Characteristics and Models of Solid State Devices II-B (2QH)
Spring Quarter
Continuation of ECE 3389, Prep. ECE 3389.

ECE 3391 Computer Architecture (4QH)
Winter Quarter
This course deals with the design of new architectures as well as understanding those already extant. Both the hardware and system software which permit the system to deal with multiple processes sharing common resources such as a processor, a bus, primary memory and disk storage are considered. Topics include the operating system, caches and memory management, and I/O processing. The software topics include some exercises in a small subset of VAX assembly language, typical HLL constructs and their translation to VAX assembly code, instruction and addressing mode frequencies, and consideration of the value of different data types. RISC and CISC architectures are introduced and issues concerning the subdivision of computational tasks and hard-wiring vs. microprogramming are discussed. Details of a specific design are introduced to focus on solving such critical operations as pipeline design and efficient interrupt handling. Prep. A good working knowledge of high-level-language programming (Pascal or C, for example), a course in logic (gates, minimization, sequential and combinatorial circuits), and at least a rudimentary idea of assembly language programming and how a computer functions internally.

ECE 3392 Digital Computer Architecture A (2QH)
Fall and Winter Quarters
ECE 3392 and ECE 3393 cover the same material with the same prerequisites as ECE 3391, but in two 2QH courses.

ECE 3393 Digital Computer Architecture B (2QH)
Winter and Spring Quarters
Continuation of ECE 3392. Prep. ECE 3392.

ECE 3394 Microprogramming (2QH)
Spring Quarter
Topics in microprogramming and emulation including microprogramming concepts and techniques; microprogramming design approach using register transfer notation and precedence graphs; microprogrammed computers, bit-slice microprogramming, microprogramming a specific machine for emulation using a microprogramming language and its simulator; current trends in microprogramming languages and support tools. Prep. ECE 3391 or 3393.

ECE 3395 VLSI Design (4QH)
Fall Quarter
VLSI design methodology; MOS devices and circuits; layouts, design rules; fabrication process; evaluation of area, power and propagation delay; CMOS subsystem design; system clocking; CAD tools, simulation, placement and routing; testing, fault models, test vector generation; laboratory design project going through a complete VLSI design cycle. Prep. ECE 3101 and ECE 3103 or equivalent.

ECE 3396 VLSI Design A (2QH)
Fall Quarter
ECE 3396 and ECE 3397 cover the same material with the same prerequisites as ECE 3395, but in two 2QH courses.

ECE 3397 VLSI Design B (2QH)
Winter Quarter
Continuation of ECE 3396. Prep. ECE 3396.

ECE 3398 VLSI Architectures (4QH)
Winter Quarter
Review of VLSI design methodology; pipelining and parallel processing in VLSI; interconnection between VLSI processing units; VLSI oriented algorithms and applications; algorithm to architecture compilation; special VLSI architectures, systolic arrays and wavefront arrays; implementation of VLSI processors; design for testability; fault tolerant VLSI architectures; research project. Prep. ECE 3395.

ECE 3399 VLSI Architectures I (2QH)
Winter Quarter
ECE 3399 and 3400 cover the same material with the same prerequisites as ECE 3398, but in two 2 QH courses. Prep. ECE 3395.

ECE 3400 VLSI Architectures B (2QH)
Spring Quarter
Continuation of ECE 3399. Prep. ECE 3399.

ECE 3401 Digital Systems Design with Hardware Description Languages (4QH)
Spring Quarter
This course covers design, simulation, modeling, and implementation of complex digital systems using high level computer hardware description languages (HDL). It begins with a description of digital system design hierarch, and abstraction. Next a brief overview of available design tools and simulation programs will be given. HDLs, with emphasis on VHDL and AHPL will then be introduced. Using these languages for design and verification of digital systems at different levels of abstraction will be studied. Students will use VHDL software for design and simulation of large digital circuits. Silicon compilation, computer-aided design and automatic generation of hardware will also be addressed. Prep. ECE 3391.

ECE 3402 Digital Systems Design with Hardware Description Languages - A (2QH)
Fall Quarter
ECE 3402 and ECE 3403 cover the same material with the same prerequisites as ECE 3401, but in two 2QH courses. Prep. ECE 3391.

ECE 3403 Digital Systems Design with Hardware Description Languages - B(2QH)
Winter Quarter
Continuation of ECE 3402. Prep. ECE 3402.

ECE 3412 Power System Planning (4QH)
Spring Quarter
Engineering and economic considerations underlying the planning and development of modern interconnected power systems. Consideration of overall planning strategies involved in economic comparison of alternative development schemes. Prep. ECE 3120.

ECE 3415 Power Systems Protection (2QH)
Winter Quarter
Consideration of protection applied to generation, transmission, and distribution. Investigation of the characteristics and operating principles of various methods of protective relaying; analysis of current techniques pertaining to system protection. Prep. ECE 3303.

ECE 3416 Power System Transients (2QH)
Fall Quarter
Transients in power systems due to system switching, lightning, or faults. Traveling-wave phenomena; insulation coordination; overvoltages due to disturbances on the system; surge protection. Prep. ECE 3303.

ECE 3423 Special Topics in Power (2QH)
Spring Quarter
Directed reading and discussion of topics of special interest in the power field. Series of lectures by guest speakers from industry on topics of particular interest to the power student. Prep. Permission of Instructor.

ECE 3424 Power System Dynamics (2QH)
Spring Quarter
Transient system models; small and large scale oscillations; solution of swing equation for single and multi-generator cases; load frequency and voltage controllers and transient stability. Prep. ECE 3303.

ECE 3430 Studies in Electric Power Transmission I (2QH)
Fall Quarter
Elements in the design of AC overhead transmission lines; thermal limitation, series and shunt compensation, environmental effects; consideration of transposition, induced effects, and insulation level. Underground alternatives to overhead lines. Elements of distribution. Prep. ECE 3303.

ECE 3431 Studies in Electric Power Transmission II (2QH)
Winter Quarter
Fundamental concepts of high voltage DC power transmission; rectifier and inverter performance; regulation; protection; reactive power and filter requirements; practical arrangement of DC lines; the impact of a DC line on overall power system operation. Prep. ECE 3303.

ECE 3443 Theory of Computation (4QH)
Spring Quarter
This course deals with basic abstract models of computation. Topics include Turing machines, primitive recursive functions, recursive systems of equations and abstract families of algorithms.

Unsolvable problems are examined, along with the Recursion Theorem. Prep. ECE 3200.

ECE 3444 Theory of Computation A (2QH)
Fall Quarter
ECE 3444 and ECE 3445 cover the same material with the same prerequisites as ECE 3443, but in two 2QH courses.

ECE 3445 Theory of Computation B (2QH)
Winter Quarter
Continuation of ECE 3444. Prep. ECE 3444.

ECE 3447 Switching Theory I (4QH)
Spring Quarter
Logical design of combinational switching circuits, including minimization and decomposition of switching functions; multiple output networks; symmetric networks; threshold logic, fault detection. Logic design of sequential switching circuits including finite-state machine model; iterative networks; capabilities and limitations of finite-state machines; state equivalence; synthesis of asynchronous sequential circuits; state assignment problem and partition theory; machine decomposition. Logical design of sequential switching circuits, including the finite-state machine model; iterative networks; capabilities and limitations of finite-state machines; state equivalence; synthesis of asynchronous sequential circuits; state assignment problem and partition theory; machine decomposition. Prep. ECE 3200.

ECE 3448 Switching Theory I-A (2QH)
Fall Quarter
ECE 3448 and ECE 3449 cover the same material with the same prerequisites as ECE 3447, but in two 2QH courses.

ECE 3449 Switching Theory I-B (2QH)
Winter Quarter
Continuation of ECE 3448. Prep. ECE 3448.

ECE 3450 Switching Theory II (2QH)
Spring Quarter
Selected topics from the theory of finite automata, including such topics as machine experiments; information lossless machines; linear sequential machines; finite-state recognizers. Prep. ECE 3447 or 3449.

ECE 3451 Combinatorial Methods and Optimization Techniques (4QH)
Spring Quarter
An introductory course in applied combinatorial mathematics which treats selected topics in enumerative analysis. Particular subjects include permutations, combinations, generating functions, recurrence relations, and the principle of inclusion and exclusion. Polya's theory of counting; selected topics in optimization techniques, which include transport networks, matching theory, linear programming, and an introduction to dynamic programming. Prep. ECE 3200

ECE 3452 Combinatorial Methods and Optimization Techniques A (2QH)
Winter Quarter
ECE 3452 and ECE 3453 cover the same material with the same prerequisites as ECE 3451, but in two 2QH courses.

ECE 3453 Combinatorial Methods and Optimization Techniques B (2QH)
Spring Quarter
Continuation of ECE 3452. Prep. ECE 3452.

ECE 3454 Graph Theory (2QH)
Spring Quarter
Fundamentals of graph theory, including blocks, trees, connectivity, partitions, traversability, line graphs, factorization, coverings, planarity, matrices, digraphs, and enumeration problems. Selected applications of graph theory in such fields as network theory, switching theory, and computer science. Prep. ECE 3211.

ECE 3460 Special Topics in Computer Engineering (2QH)
Spring Quarter
Aspects of computer engineering not covered in other courses. The subject matter may change from year to year.

ECE 3463 Robot Vision and Sensors (4QH)
Winter Quarter
Methods of acquisition, representation and processing of real world information for robot control. A major portion of the course focuses on the different aspects of robot vision. Topics include: projection , lens distortion, image noise reduction, texture, edge-based systems, region-based

systems, Hough space, matched filtering, object modeling, stereo vision, motion, and optical flow. Robot sensors covers a variety of sensor types including force/torque, proximity, and tactile sensors. Prep. ECE 3466.

ECE 3464 Robot Vision and Sensors A (2QH)
Winter Quarter
ECE 3464 and ECE 3465 cover the same material with the same prerequisites as ECE 3463, but in two 2QH courses.

ECE 3465 Robot Vision and Sensors B (2QH)
Spring Quarter
Continuation of ECE 3464. Prep. ECE 3464.

ECE 3466 Robotics and Automation Systems (4QH)
Fall Quarter
Methods of design and operation of general purpose and industrial manipulator systems. Robot mobility criteria. Kinematic and dynamic models of mechanical arms. Joint solutions and motion characteristics. Trajectory planning. Arm control through coordinate transformations, classical feedback methods and modern closed-loop control techniques. Real-time control of robotic systems. Prep. ECE 3221.

ECE 3467 Robotics and Automation Systems A (2QH)
Fall Quarter
ECE 3467 and ECE 3468 cover the same material with the same prerequisites as ECE 3466, but in two 2QH courses.

ECE 3468 Robotics and Automation Systems B (2QH)
Winter Quarter
Continuation of ECE 3467. Prep. ECE 3467.

ECE 3469 Fault-Tolerant Computers (4QH)
Spring Quarter
Concepts of computer systems structures and specifications; software and hardware interactions; failure and reliability; errors and faults. Study of different types of faults; fault prevention and fault tolerance; redundancy management; reliability and availability. Comparisons of existing fault-tolerant computer architectures such as SIFT, FTMP, Tandem 16, and Stratus/32. Techniques of error detection and error recovery. Mechanisms for damage confinement and damage assessment. Study of software fault tolerance techniques such as recovery block scheme, deadline mechanism, and N-version programming scheme. Prep. ECE 3391.

ECE 3470 Fault-Tolerant Computers A (2QH)
Winter Quarter
ECE 3470 and ECE 3471 cover the same material with the same prerequisites as ECE 3469, but in two 2QH courses.

ECE 3471 Fault-Tolerant Computers B (2QH)
Spring Quarter
Continuation of ECE 3470. Prep. ECE 3470.

ECE 3472 Special Topics in Robotics
Spring Quarter
This course focuses on the many aspects of building real world intelligent robot systems. Intelligent robots are composed of sensing modules, reasoning modules, and action modules. This course focuses on the integration of sensing, reasoning, and action to build real-world intelligent robot systems. Topics inlcude software control architectures, world modeling, sensing, trajectory planning, sensor fusion, reasoning, and robot hardware requirements. Prep. ECE 3463,3466.

ECE 3473 Parallel Architectures for Signal Processing (4QH)
Fall Quarter
Parallel processing techniques for real-time signal/image processing applications, data flow analysis for parallelism extraction, mapping algorithms to architectures. Linear, 2-D and 3-D systolic/wavefront arrays, partitioning and matching algorithms to fixed size arrays. Case studies in adaptive filtering, array beam-forming, speech/character recognition, image processing, graph theoretic problems, etc. Concurrnet languages for parallel processing, design tools for parallel architectures, mapping automation, array compilers. Run-time fault tolerance issues in processor arrays. Neuro-computing models for signal/image processing, deriving parallel architectures for neural networks, VLSI implementation issues.

ECE 3476 Special Topics in Fault Tolerant Computing (4QH)
Winter Quarter
Fault tolerant VLSI/WSI processor arrays: fault and error models for VLSI, reconfiguration techniques for run-time fault tolerance, graceful degradation, transient fault recovery, time redundancy, fabrication and compile time array restructuring for yield enhancement in wafer scale integration arrays. Unify fault tolerance with the mapping of algorithms to VLSI array structures. Fault tolerant communication structures: relieable shared memory and message passing mechanisms, fault tolerant loops, trees, hypercubes, etc. Dynamically reconfigurable networks. System level diagnosis, diagnosability analysis-the-PMC model, distributed diagnosis, software fault tolerance, N- version programming, recovery blocks. Prep. ECE 3469 or permission of instructor.

ECE 3477 Testing and Design for Testability(4QH)
Fall Quarter
This course encompasses the theoretical and practical aspects of digital systems testing and the design of easily testable circuits. Major topics for the course include defect and fault models, test generation for combinational and sequential circuits, testing measures and costs, functional and parametric test methods, design for testability, built-in self test, and concurrent testing. The objective of the course is to provide the foundations for developing test methods for digital systems and to provide the techniques necessary to practice design for testability. Prep. 3395.

ECE 3480 Distributed Systems (4QH)
Spring Quarter
This course covers fundamentals of distributed systems, distributed computing models, client-server computing, remote procedure calls, distributed file and directory services, distributed systems design and implementation issues, reliability and availability, security, overview of computer networks, and case studies in distributed systems. Prep. Undergraduate course in Operating Systems.

ECE 3483 Multiprocessor Architectures (4QH)
Fall Quarter
This course covers fundamental structures of multiprocessor computer architectures, memory organization and interconnection networks, cache coherence issues, operating systems and programming languages support for multiprocessors, dataflow concepts, and a survey of some novel implementations of multiprocessors. Prep. Introductory course in Computer Architecture.

ECE 3497 Statistical Signal Processing (4QH)
Spring Quarter
Introduction to Statistical Signal Processing: Optimum (Wiener) Filtering: principle of orthogonality, the whitening filter and the innovations process, autoregressive signals; Finite-Order Linear Prediction: Yule-Walker equations, forward and backward prediction, the Levinson and Schur algorithms, the lattice filter configuration, multichannel lattice filters, linear prediction for nonstationary signals, dedicated multiprocessor array realizations; Applications to adaptive signal processing, spectrum estimation, and array processing; Autocorrelation/Spectrum Estimation: sample autocorrelation and its statistical properties, non-parametric spectrum estimation, the maximum-entropy method, Burg's algorithm, stationary spectra associated with nonstationary signals. Prep. ECE 3321 and ECE 3241.

ECE 3498 Statistical Signal Processing A (2QH)
Fall Quarter
ECE 3498 and 3499 cover the same material with the same prerequisites as ECE 3497, but in tow 2QH courses. Prep. ECE 3321 and ECE 3241.

ECE 3499 Statistical Signal Processing B (2QH)
Winter Quarter
Continuation of ECE 3498. Prep. ECE 3498.

ECE 3500 Auditory Signal Processing (4QH)
Fall Quarter, As Announced
This course provides engineers interested in the processing and production of audio signals with knowledge of how sounds are processed and perceived in the auditory system by exploring physiological and psychological acoustics. Special emphasis is placed on mathematical models

of the auditory system. Topics covered include: properties of acoustical stimuli; anatomy and physiology of the auditory system; electrical recordings from the auditory system; methods of psychophysical measurements; absolute thresholds; temporal integration; masking and auditory frequency analysis; signal detection theory and models of masking; frequency and intensity discrimination; experiments and models on temporal processing; loudness; Zwicker's loudness summation model; pitch perception; binaural hearing; other perceptual continua; timbre, roughness, noisiness, and annoyance. After completing the course, students will have a thorough understanding of the auditory processes that govern perception of sounds and are fundamental to our ability to understand speech. Prep. ECE 3241 or equivalent.

ECE 3502 Special Topics in Digital Signal Processing - Fast Algorithms (2QH)
Fall Quarter
Fast algorithms for implementation of digital filters and discrete Fourier transforms: FFT, convolution algorithm, Number Theoretic Transforms (NTT), filtering computation, and polynomial transforms. Prep. ECE 3321.

ECE 3503 Two-Dimensional Digital Signal Processing (2QH)
Winter Quarter
Two-dimensional digital signal processing which is finding wide applications in many diversified areas. Covers 2-D shift invariant systems along with their stability, the 2-D Discrete Fourier Transform (DFT) and its FFT implementation,

ECE 3505 Digital Image Processing (4QH)
Spring Quarter
Topics include: generation of digital image from the source, image digitizers and display devices, image transforms, enhancement techniques such as histogram, equalization, edge sharpening etc.; restoration by Wiener and Kalman filters, image coding using run length coding, DPCM, transform coding and feature analysis. Prep. ECE 3321.

ECE 3506 Digital Image Processing A (2QH)
Fall Quarter
ECE 3506 and ECE 3507 cover the same material with the same prerequisites as ECE 3505, but in two 2QH courses.

ECE 3507 Digital Image Processing B (2QH)
Winter Quarter
Continuation of ECE 3506. Prep. ECE 3506.

ECE 3508 Modern Spectral Analysis (4QH)
Fall Quarter
Introduction; conventional methods of spectrum estimation: periodogram and autocorrelation methods with their smooth versions; the maximum entropy method with and without uncertainty in the correlation measurements; the Levinson algorithm; the minimum energy method, weighted Burg techniques, forward-backward least-squares, covariance least-squares; moving average (MA) and ARMA spectrum estimation; model order selection criteria; harmonic decomposition methods: Prony, Pisarenko and singular value decomposition methods; introduction to multichannel conventional spectrum estimation techniques; parametric modeling of multichannel time series; the Levinson-Wiggins-Robbins algorithm; multichannel AR spectrum estimation techniques. Prep. ECE 3321.

ECE 3509 Modern Spectral Analysis A (2QH)
Fall Quarter
ECE 3509 and 3510 cover the same material with the same prerequisites as ECE 3508, but in two 2 QH courses. Prep. ECE 3321.

ECE 3510 Modern Spectral Analysis B (2QH)
Winter Quarter
Continuation of ECE 3509. Prep. ECE 3509.

ECE 3511 Data Communications Networks (4QH)
Spring Quarter
Data networks fundamentals and layering; data link control layer; elements of queueing theory; networks with multi-access channels; local and metropolitan area networks: network layer (routing and flow control); perfomance evaluation. Prep. ECE 3241.

ECE 3512 Data Communications Networks A (2QH)
Winter Quarter
ECE 3512 and ECE 3513 cover the same material with the same prerequisites as ECE 3511, but in two 2QH courses.

ECE 3513 Data Communications Networks B (2QH)
Spring Quarter
Continuation of ECE 3512. Prep. ECE 3512.

ECE 3514 Error Correcting Codes (4QH)
Spring Quarter
Error correcting codes and their decoding techniques which show promise for applications in digital communication, control and computer systems. Emphasis is placed on the linear block codes based on algebraic structures; cyclic codes for random error correction (B-C-H codes) and burst error correction. Convolutional codes and decoding including the Viterbi algorithm, arithmetic codes. Combination of codes. Coding for ranging and synchronization. Prep. ECE 3211.

ECE 3515 Error Correcting Codes A (2QH)
Winter Quarter
ECE 3515 and ECE 3516 cover the same material
with the same prerequisites as ECE 3514, but in two 2QH courses.

ECE 3516 Error Correcting Codes B (2QH)
Spring Quarter
Continuation of ECE 3515. Prep. ECE 3515.

ECE 3517 Information Theory A (2QH)
Winter Quarter
ECE 3517 and 3518 cover the same material with same prerequisites as ECE 3519, but in two QH courses. Prep. ECE 3241 and 3351.

ECE 3518 Information Theory B (2QH)
Spring Quarter
Continuation of ECE 3517.

ECE 3519 Information Theory (4QH)
Fall Quarter
Mathematical models for information sources and communication channels. Entropy mutual information, divergence and their properties. Data translation codes for noiseless channels, RLL codes. Capacity of input restricted noiseless channels. Data compaction codes and uniquely decodable codes. The asymptotic equipartition property (AEP), Shannon's first coding theorem (noiseless coding theorem). Huffman code and other source coding schemes. Data transmission codes, capacity of a communication channel. Shannon's second coding theorem (noisy channel coding theorem). Channel reliability function and its properties. Data compression codes, distortion measure and the rate distortion function. Shannon's (source coding theorem with a fidelity criterion). Continuous channels and sources, Gaussian sources and channels, capacity of the discrete-time additive Gaussian noise channels. Rate distortion function for the Gaussian sources, Gaussian waveform channels, and sources. Basic concepts of multi-terminal information theory. Prep. ECE 3241 and 3351.

ECE 3520 Special Topics in Communication Theory (2QH)
Spring Quarter
Current aspects of communication theory not covered in previous courses. Subject matter may change from year to year. Prep. ECE 3241 and 3351.

ECE 3521 Multidimensional Spectrum Estimation (2QH)
Spring Quarter
Introduction; stationary random fields and their spectrum representation; place waves and their frequency-wavenumber spectrum; conventional methods (FFT based) and m-d window functions; m-d maximum likelihood method of Capon; 2-d maximum entropy methods; the extendibility problem in spectrum estimation; m-d parametric models for spectrum estimation: separable methods, m-d AR methods, techniques based on minimum variance representations, 2-d ARMA methods; the m-d Prony and Pisarenko methods. Prep. ECE 3503 and 3508.

ECE 3522 Array Signal Processing (2QH)
Spring Quarter
Array systems: configurations, cost, complexity, narrowband and wideband systems; problem formulation; duality between spectrum estimation

and array processing; array processing methods: beamforming, minimum variance distortionless, autoregressive, thermal noise, music; coherent vs. incoherent sources; adaptive array processing: sidelobe cancellation, interference rejection, LMS algorithm; wideband array processing techniques; applications to sonar, radar, geophysics and biomedicine. Prep. ECE 3321.

ECE 3523 Communication Systems (4QH)
Fall Quarter
Primarily concerned with radio communication systems as used in terrestrial and space communication applications. Antenna gain, space loss, cosmic and atmospheric noise, and receiver noise are considered as factors influencing the signal-to-noise ratio in space and satellite repeater systems. Contemporary systems are discussed from the standpoint of signal spectrum, noise power and message ambiguity as exhibited at the output of the intermediate frequency receiver. The theoretical aspects of amplitude and angle modulation systems are introduced and extended to cover multiplex systems; signal-to-noise ratio analysis of frequency multiplex systems; time division multiplex systems. Coverage of digital systems will include sampling, aliasing, and PCM/FM. Bit stream organization for transmission will be considered. A PCM encoder will be discussed as a means of matching the bit stream to the bandwidth. Illustrative examples will be drawn from contemporary communications systems used on balloons, rockets, and satellite repeaters. Prep. ECE 3241 and ECE 3104 or equivalent.

ECE 3524 Communication Systems A (2QH)
Fall Quarter
ECE 3524 and ECE 3525 cover the same material with the same prerequisites as ECE 3523, but in two 2QH courses.

ECE 3525 Communication Systems B (2QH)
Winter Quarter
Continuation of ECE 3524. Prep. ECE 3524.

ECE 3526 Nonlinear Systems (4QH)
Fall Quarter, As Announced
Operators and functionals. The Volterra series representation of nonlinear systems. System Transforms. Application of the Volterra theory to nonlinear system analysis: P-th order system inverses; The analysis of nonlinear feedback systems, circuits with nonlinear elements, and systems characterized by nonlinear differential equations. Introduction to orthogonal functionals. Prep. ECE 3108 or equivalent.

ECE 3527 Nonlinear Systems A (2QH)
Fall Quarter, As Announced
ECE 3527 and ECE 3528 cover the same material with the same prerequisites as ECE 3526, but in two 2QH courses.

ECE 3528 Nonlinear Systems B (2QH)
Winter Quarter, As Announced
Continuation of ECE 3527. Prep. ECE 3527.

ECE 3529 Nonlinear Systems II (2QH)
Spring Quarter, As Announced
Analysis of nonlinear systems with random inputs. The Wiener G-functionals, Nonlinear System identification. The Wiener model. The Gate functionals and their application to nonlinear system modeling and nonlinear filtering. Optimization of nonlinear models. Prep. ECE 3526 and 3241.

ECE 3530 Three-Dimensional Picture Processing (2QH)
Spring Quarter, As Announced
The application of computer, optical, and analytic methods in abstracting geometrical information from pictures. Pictorial presentation of data trains into multidimensional pictures. Methods will be studied for reconstructing three-dimensional objects from two-dimensional pictures. Applications will be in the areas of X-ray analysis, radar target identification, microscopy, and sensory perception. Students will have the chance to pursue individual projects during the term. Prep. ECE 3321.

ECE 3531 Adaptive Signal Processing (4QH)
Fall Quarter
Introduction; Optimum filtering (Wiener-Kalman); Signal and system modeling using linear prediction; Adaptive filtering (FIR, IIR); Fast algorithms for Least Squares adaptive filters; Adaptive array processing; VLSI architectures for adaptive signal processing. Prep. ECE 3497.

ECE 3532 Adaptive Signal Processing A (2QH)
Fall Quarter
ECE 3532 and ECE 3533 cover the same material with the same prerequisites as ECE 3531, but in two 2 QH courses. Prep. ECE 3497.

ECE 3533 Adaptive Signal Processing B (2QH)
Winter Quarter
Continuation of ECE 3532. Prep. ECE 3532.

ECE 3534 Digital Processing of Speech Signals (4QH)
Spring Quarter
Analysis and recognition of speech using computer techniques. Introduction to speech physiology, linguistics, phonetics, and acoustics. Models of speech production. Short-term processing of speech - temporal features, Fourier analysis, applications. Theory of linear predictive coding and applications. Homomorphic analysis of speech and applications. Speech and speaker recognition. Prep. ECE 3321.

ECE 3535 Digital Processing of Speech Signals A (2QH)
Fall Quarter
ECE 3535 and ECE 3536 cover the same material with the same prerequisites as ECE 3534, but in two 2 QH courses. Prep. ECE 3321.

ECE 3536 Digital Processing of Speech Signals B (2QH)
Winter Quarter
Continuation of ECE 3535. Prep. ECE 3535.

ECE 3537 Multi-User Communication Systems (4QH)
Spring Quarter
Contention-free multiple-access techniques: frequency-division multiple-access (FDMA), time-division multiple-access (TDMA). Spread-spectrum multiple-access (SSMA) communications: Direct-sequence SSMA, frequency-hop SSMA, and hybrid SSMA systems. Communication networks: queuing theory, multiple-access with contention (ALOHA random-access and tree algorithms for random-access), network routing and flow control (quasi-static control versus dynamic control). An overview of the applications of multi-user communication systems: computer-communication networks, broadcast satellite systems, military communications, mobile radio communications, packet-radio communication networks, and fiber-optic local-area networks. Prep. ECE 3351.

ECE 3538 Multi-User Communication Systems A (2QH)
Winter Quarter
ECE 3538 and ECE 3539 cover the same material with the same prerequisites as ECE 3537, but in two 2 QH courses.

ECE 3539 Multi-User Communication Systems B (2QH)
Spring Quarter
Continuation of ECE 3538. Prep. ECE 3538.

ECE 3540 Digital Control Systems (4QH)
Winter Quarter
Analysis of linear discrete-time dynamic systems; discretization of continuous systems; sampling and aliasing. Design of digital control systems using transform techniques by discrete equivalent and direct design methods; root locus, Bode and Nyquist diagrams and Nichols charts. Multivariant digital control using state-space methods; pole placement, observer, and regulator design. Controller implementation issues: digital filter realizations, nonlinear effects due to quantization, roundoff, deadband, limit cycles. Selection of the sampling rate. Prep. ECE 3221 and 3381.

ECE 3541 Digital Control Systems A (2QH)
Fall Quarter
ECE 3541 and ECE 3542 cover the same material with the same prerequisites as ECE 3540, but in two 2QH courses.

ECE 3542 Digital Control Systems B (2QH)
Winter Quarter
Continuation of ECE 3541. Prep. ECE 3541.

ECE 3546 Advanced Topics in Stochastic and Nonlinear Systems (4QH)
Winter Quarter
Current research topics in stochastic systems and nonlinear dynamics. Areas to be covered will be chosen from the following: Large deviations and stochastic optimization. Stochastic stability. Glo

bal dynamics, bifurcations and singular perturbations. Nonlinear circuit examples. Prep. ECE 3543

ECE 3547 Advanced Topics in Stochastic and Nonlinear Systems A (2QH)
Winter Quarter
ECE 3547 and ECE 3548 cover the same material with the same prerequisites as ECE 3546, but in two 2QH courses.

ECE 3548 Advanced Topics in Stochastic and Nonlinear Systems B (2QH)
Spring Quarter
Continuation of ECE 3547. Prep. ECE 3547.

ECE 3549 Multivariable Control Systems (4QH)
Spring Quarter
Mathematical preliminaries, polynomial and polynomial matrices; representations of linear multivariable system; matrix fraction description (MFD) and polynomial matrix description (PMD); responses of linear multivariable systems; controllability, observability and canonical forms; poles and zeros of multivariable systems; stability; realization problem; interaction control; state feedback and observer design; compensator design, stability and robustness; noninteraction control; frequency domain design techniques. Prep. ECE 3221 & 3381.

ECE 3550 Multivariable Control Systems A (2QH)
Fall Quarter
ECE 3647 and ECE 3648 cover the same material with the same prerequisites as ECE 3646, but in two 2 QH courses. Prep. ECE 3321 and 3381.

ECE 3551 Multivariable Control Systems B (2QH)
Winter Quarter
Continuation of ECE 3647. Prep. ECE 3647.

ECE 3552 System Identification and Adaptive Control (4QH)
Fall Quarter
Identification is the process of mathematically modeling a system based on measurement data that may be limited or uncertain. Adaptive control, then, is the means whereby a system that is poorly modeled is controlled adequately. The purpose of the system identification portion of the course is to enhance the underlying basic ideas, which are essential for adaptive control. Particular emphasis is given to recursive approaches, such as recursive least square algorithm, where parameter estimates are updated in real-time. The adaptive control portion of the course covers simple adaptive systems, adaptive observers and adaptive control. Two major adaptive schemes, namely, Model Reference Adaptive Control (MRAC) and Self-Tuning Regulators (STR) are treated in detail. Fundamental issues such as stability of adaptive systems, convergence, persistent excitation, and robustness will be discussed. An important by-product of the course is that the students will identify several points of tangencies between two areas of control systems and signal processing. Prep. ECE 3221 and ECE 3321.

ECE 3555 Statistical Pattern Recognition and Neural Networks (4QH)
Quarter
Pattern recognition problems arise in many areas of practical importance such as character recognition, computer vision, biomedical pattern classification and speech recognition. In this course pattern recognition problems are approached from a statistical point of view. Also neural networks as means of pattern recognition are studied. The subjects covered include: Bayes decision theory, discriminant functions, supervised and unsupervised learning, nearest neighbor classifiers, perception training algorithm, speech recognition, neural network fundamentals, feedforward neural networks and the back propagation algorithm, feedback neural networks, stable states, associative memory, capacity of neural networks. Prep. ECE 3241.

ECE 3556 Special Topics in System Theory (4QH)
Spring Quarter
Current aspects of system theory not covered in previous courses. Subject matter may change from year to year. Prep. ECE 3211 and ECE 3221.

ECE 3557 Special Topics in Signal Processing (4QH)
Winter Quarter
Aspects of signal processing not covered in other courses. Topics may vary from year to year. Prep. ECE 3321.

ECE 3560 Acoustics I (2QH)
Fall Quarter
The wave theory of sound. Radiation, reflection, and transmission phenomena. Distributed system analogies, and sound measurements. Prep. ECE 3341.

ECE 3561 Acoustics II (2QH)
Winter Quarter
Speech and hearing, microphones and loudspeakers, guided waves, room acoustics. Environmental acoustics. Prep. ECE 3560.

ECE 3562 Acoustics III (2QH)
Spring Quarter
Scattering and diffraction. Effects of viscosity and heat conduction. Finite amplitude and shock waves. Introduction to underwater sound. Prep. ECE 3561.

ECE 3563 Radar Systems I (4QH)
Winter Quarter
Emphasis on the systems aspects of radar engineering. Topics covered include basic theory of radar detection, measurement of range, angle, and Doppler shift; classes of radar systems; types of radar noise; components of a radar system; matched filters and correlation receivers as applied to radar systems; fundamental ideas of radar system analysis. In-depth study of search radar theory; maximum likelihood estimation approach to measurement of radar target parameters; resolution and ambiguity functions applied to radar; radar parameter uncertainty principles. Prep. ECE 3241.

ECE 3564 Radar Systems I-A (2QH)
Fall Quarter
ECE 3564 and ECE 3565 cover the same material with the same prerequisites as ECE 3563, but in two 2QH courses. Prep. ECE 3241.

ECE 3565 Radar Systems I-B (2QH)
Winter Quarter
Continuation of ECE 3564. Prep. ECE 3564.

ECE 3566 Radar Systems II (2QH)
Spring Quarter
Advanced topics in radar systems engineering. Topics to be covered include: design considerations for multistatic radar systems, synthetic aperture radars; tracking systems; radar waveform synthesis; multifunction array radar techniques and selected topics in radar sensing techniques and devices. Prep. ECE 3563 or 3565.

ECE 3567 Network Information Theory (4QH)
Fall Quarter
This course deals with the fundamental limits on information compression and transmission in multiuser communication network from an information theoretic point of view. Topics covered in this course include: basics of point-to-point information theory, conditional AEP, capacity of channels with feedback, joint coding of correlated sources, source coding with side information, data compression with side information, multiple access channels, feedback in multiple access channels, broadcast channels and superposition coding, two-way channels, the wiretap channel. Prep. ECE 3241.

ECE 3571 Fourier Optics (4QH)
Fall Quarter
This course covers: optical diffraction and imaging problems as linear systems; necessary tools of Fourier analysis and linear systems analysis which occur when solving the scalar wave equation; waves and their properties; reflection, refraction, polarization, and propagation of waves; foundations of scalar diffraction theory -- including Fresnel and Fraunhofer diffraction, interferometry, division of amplitude, division of wavefront, interferometric instrumentation, Fourier transforming, image properties of lenses, coherent and incoherent imaging; and advanced topics in the application of communication theory to optical problems, transfer and spread functions, spatial filtering, and holography. Prep. ECE 3581.

ECE 3572 Fourier Optics I-A (2QH)
Winter Quarter
ECE 3572 and ECE 3573 cover the same material with the same prerequisites as ECE 3571, but in two 2QH courses. Prep. ECE 3581 or 3582.

ECE 3573 Fourier Optics I-B (2QH)
Spring Quarter
Continuation of ECE 3572. Prep. ECE 3572.

ECE 3574 Fourier Optics II (2QH)
Fall Quarter
Covers current topics of interest in Fourier optics and optical instrumentation. Application of coherence phenomena to optical instrumentation such as microdensitometers, microscopes, viewers, cameras, spectraphotometric and interferometric instruments; applications of holography, optical data processing and computing, holographic memories, optical modulation, noise and its effects on data collection, synthetic aperture optics and medical application of laser optics. Prep. ECE 3573 or 3571.

ECE 3576 Lasers I (2QH)
Fall Quarter
Review of basic optical principles and atomic physics; introduction to optical coherence; models for the interaction of electromagnetic radiation with matter; a general description of lasers is given. Prep. ECE 3341.

ECE 3577 Lasers II (2QH)
Winter Quarter
Laser threshold and rate equations; elementary resonator theory and fabrication; giant pulse operation; specific solid-state, liquid, and gas lasers; and laser systems. Prep. ECE 3576.

ECE 3578 Lasers III (2QH)
Spring Quarter
Applications of lasers and laser systems for a variety of engineering and basic science disciplines; specific laser optoelectronic devices. Prep. ECE 3577.

ECE 3579 Optoelectronics and Fiber Optics (2QH)
Winter Quarter
Overview and analysis of the various elements and their characteristics which are utilized in optical communication systems, including elements which generate, transfer, and detect optical signals. Topics include resonance and guiding phenomena, semiconductor physics, LED's, lasers, diode detectors, optical waveguide theory and design, optical communication systems criteria. Prep. ECE 3580.

ECE 3580 Electro-Optics I (2QH)
Spring Quarter
Survey of the basic concepts necessary for understanding and evaluating the optics involved in electro-optical systems. The optical system as a linear system; matrix methods; diffraction and interference; imaging and aberrations. Prep. Bachelor of Science Degree in Engineering or Physics.

ECE 3581 Electro-Optics II (2QH)
Fall Quarter
Survey of the basic concepts necessary for understanding electro-optical devices. Wave propagation in isotropic and nonisotropic media; optics of crystals; polarization; optical resonators; guided waves; modulators and detectors; thin film optics. Prep. ECE 3580.

ECE 3582 Electro-Optics (4QH)
Spring Quarter
This course covers the same material as in ECE 3580 and 3581. Prep. BS in Engineering or Physics.

ECE 3583 Optical Properties of Matter I (2QH)
Fall Quarter
Optics of crystals; classification and effects of crystal symmetry on optical properties; classical description of wave propagation in crystals; applications of the theory to modulation, pulse generation, nonlinear optics. Prep. Bachelor of Science Degree in Engineering or Physics.

ECE 3584 Optical Properties of Matter II (2QH)
Winter Quarter
Introduction to electro-optical and magneto-optical effects in material media; linear and nonlinear optical materials; elasto-optic and acousto-optical materials; polarization and propagation effects; modulation. Prep. ECE 3583.

ECE 3585 Optical Properties of Matter III (2QH)
Spring Quarter
Thin films and optical fibers; multilayer filters; dichroics; integrated optics. Prep. ECE 3584.

ECE 3586 Principles of Optical Detection (4QH)
Spring Quarter
The emphasis of this course is on the detector as a component of an optical system. Topics include the laws governing radiation and radiometry, properties of real radiation sources, detailed descriptions of detection devices, noise, contrast, and MTF, imaging and ranging devices, electro-optical detector systems analysis. It also includes practical consideration in real detectors, resolution and recognition of signals, heterodyne detection, sub-nanosecond pulse detection, and calibration of electro-optical detectors. Prep. BS Degree in Engineering or Physics.

ECE 3587 Principles of Optical Detection A (2QH)
Winter Quarter
ECE 3587 and 3588 cover the same material with the same prerequisites as ECE 3586, but in two 2QH courses. Prep. BS Degree in Engineering or Physics.

ECE 3588 Principles of Optical Detection B (2QH)
Spring Quarter
Continuation of ECE 3587. Prep. ECE 3587.

ECE 3589 Optical Storage and Display (2QH)
Fall Quarter
Survey of materials and methods for the storage and display of information. Topics included are: photographic film, holograms, storage tubes, magneto-optical films, photochromic materials, electro-optical crystals, evaporated thin films and liquid crystals. Prep. Bachelor of Science in Engineering or Physics.

ECE 3590 Optical Instrumentation Design (2QH)
Fall Quarter
An introduction to the design of optical instrumentation. Principles and basic concepts of optical systems. In sequence the topics are: introduction, mechanical shock and vibration, kinematic designs; application of third order aberrations, simple optical ray tracing, optical testing, tolerances, optical instrumentation, philosophy, functional design, design for quantity production, quality assurance, "special order" design, industrial design, examples and exercises. Prep. Bachelor of Science in Engineering or Physics.

ECE 3591 Spectroscopic Instrumentation (2QH)
Winter Quarter
Survey of optical instrumentation employed in analysis and control situations; modern methods of spectrometry and interferometry; optimization of analytical systems; topics in electron spectroscopy, X-ray spectroscopy, microwave spectroscopy, and related fields. Prep. ECE 3581.

ECE 3593 Plasma Engineering (4QH)
Fall Quarter, As Announced
Overview of the basic principles and applications of plasma and gaseous discharges. The topics include gas kinetics, interaction of electrons and ions with static and rf fields as well as wave propagation in plasmas. Applications in material processing, space exploration and microwave devices will also be discussed. Prep. ECE 3341.

ECE 3594 Plasma Theory (4QH)
Spring Quarter, As Announced
Introduction to the basic theory of gaseous discharges. Fluid and kinetic description of collisionless and collisional plasmas with and without magnetic field effects. Emphasis will be placed on linear stability analysis although nonlinear effects will also be discussed. Prep: ECE 3341.

ECE 3595 Plasma Theory A (2QH)
Winter Quarter, As Announced
ECE 3595 and ECE 3596 cover the same material with the same prerequisites as ECE 3594, but in two 2QH courses.

ECE 3596 Plasma Theory B (2QH)
pring Quarter, As Announced
Continuation of ECE 3595. Prep. ECE 3595.

ECE 3597 Optical Properties of Matter (4QH)
Fall Quarter
This course covers the material in ECE 3583 and 3584.

ECE 3598 Remote Sensing (4QH)
Spring Quarter
Introduction to the theory, instruments, and techniques for remote sensing of the earth. Topics include: fundamental properties of electromagnetic radiation; matter-energy interaction in the optical and microwave regions; optical imaging systems; synthetic aperture radar and side-looking airborne radar imaging systems; radar polarimetry; microwave scatterometry and radiometry; system considerations such as temporal and spatial resolution, operating frequency and bandwidth, calibration, measurement precision, and accuracy; data acquisition and storage: models and techniques for retrieving geophysical parameters from remotely sensed data; survey of current and planned airborne and spaceborne remote sensing systems and application of these sensors to measuring geophysical phenomena and monitoring global change. Prep. ECE 3341 & ECE 3241 or equivalent.

ECE 3600 Microwave Properties of Materials (4QH)
Fall Quarter
General dielectric and magnetic properties of materials; Tensor properties of dielectric and magnetic materials; Special microwave properties of thin film materials; Experimental techniques developed in the characterization of microwave materials. Prep. ECE 3102 and ME 1386 or equivalent.

ECE 3601 Microwave Properties of Materials A (2QH)
Fall Quarter
ECE 3601 and ECE 3602 cover the same materials with the same prerequisites as ECE 3600, but in two 2 QH courses. Prep. ECE 3102 and ME 1386 or equivalent.

ECE 3602 Microwave Properties of Materials B (2QH)
Winter Quarter
Continuation of ECE 3601. Prep. ECE 3601.

ECE 3603 Propagation in Artificial Structures (4QH)
Fall Quarter, As Announced
Effective dielectric and permeability constants in composite materials at high frequencies; Electromagnetic wave propagation in electrical and magnetic anisotropic media; magnetostatic and magneto-elastic wave propagation in single layer; Electromagnetic wave propagation in multi-layers. Prep. ECE 3102 or equivalent.

ECE 3604 Propagation in Artificial Structures A (2QH)
Winter Quarter, As Announced
ECE 3604 and ECE 3605 cover the same material with same prerequisites as ECE 3603, but in two 2 QH courses. Prep. ECE 3102 or equivalent.

ECE 3605 Propagation of Artificial Structures B (2QH)
Spring Quarter, As Announced
Continuation of ECE 3604. Prep. ECE 3604.

ECE 3606 Applications of Plasma Engineering (4QH)
Spring Quarter, As Announced
Basic operational principles of microwave electron devices, the theory of electric domain formation, free electron and gaseous lasers, particle beam accelerators and radiation sources. Particular topics include both classical microwave devices such as magnetrons, gyrotrons and crossed-field amplifiers, and solid state devices such as Gunn diodes and Impatt diodes. Prep. ECE 3593.

ECE 3607 Applications of Plasma Engineering A (2QH)
Winter Quarter, As Announced
ECE 3607 and ECE 3608 cover the same material with the same prerequisites as ECE 3606, but in two 2 QH courses. Prep. ECE 3593.

ECE 3608 Applications of Plasma Engineering B (2QH)
Spring Quarter, As Announced
Continuation of ECE 3607. Prep. ECE 3607.

ECE 3609 Special Topics in Electromagnetics (4QH)
As Announced
The course will concentrate on inverse problems associated with multidimensional wave equations such as the Schrodinger equation, Maxwell equations and the elastic wave equation. The

theory will be developed using both the operatior formalism employed in electromagnetic and acoustic scattering theory. Specific topics covered in the course include the inverse Sturm Liouville problem, the deterministic and random inverse source problems, inverse diffraction, and the multidimensional inverse scattering problem. The theoretical development will be accompanied by a thorough review of current applications of inverse scattering scattering theory which include structure determination using X-rays and electron probes, S-ray holography, geophysical prospecting and remote sensing, coherent radar imaging, and diffraction tomography. Prep. ECE 3231; Permission of Instructor.

ECE 3610 Electronics of Analog Signal Processing (4QH)
Spring Quarter, As Announced
Analog signal acquisition and processing utilizing state of the art devices and circuit techniques such as adaptive filters in sampled data systems, CZTs for spectral analysis, correlated double sampling for improved S/N ratios and solid state imaging systems. Linear and nonlinear processing with MOS, bipolar and CTDs such as CCDs and SAWs. Attention given to analog vs. digital approaches for implementation of similar applications, i.e., bandwidth requirements, throughput, accuracy, cost, etc. Prep. ECE 3331 and ECE 3384.

ECE 3611 Electronics of Analog Signal Processing A (2QH)
Fall Quarter, As Announced
ECE 3611 and ECE 3612 cover the same material with the same prerequisites as ECE 3610, but in two 2QH courses.

ECE 3612 Electronics of Analog Signal Processing B (2QH)
Winter Quarter, As Announced
Continuation of ECE 3611. Prep. ECE 3611.

ECE 3613 Solid State Microwave Circuits (4QH)
Spring Quarter, As Announced
This course will cover microwave circuit analysis and design using solid state devices. The topics to be discussed are negative resistance oscillators, amplifiers, detectors and mixers, microwave control circuits, frequency converters, and an introduction to CAD. A student should have the basic knowledge to undertake MMIC design. Prep. ECE 3101 or equivalent.

ECE 3614 Solid State Microwave Circuits A (2QH)
Fall Quarter
ECE 3614 and ECE 3615 cover the same material with the same prerequisites as ECE 3613, but in two 2QH courses.

ECE 3615 Solid State Microwave Circuits B (2QH)
Winter Quarter
Continuation of ECE 3614. Prep. ECE 3614.

ECE 3616 Active Network Synthesis and Design (4QH)
Fall Quarter, As Announced
Multiloop feedback techniques are developed and applied to integrated circuit designs such as three-stage Op-Amp realizations and minimum sensitivity amplifiers. Application of these circuits in continuous-time and switched-capacitor filters are treated. Single-active biquadratic filter sections of Sallen and Key and Friend-Delyannis are developed. Multiloop and multiple-active element realizations such as the generalized impedance converter (GIC), frequency-dependent negative resistance (FDNR), follow-the-leader (FLF) and leap-frog (LF) structures are discussed. Design considerations include sensitivity, yield factors, gain-bandwidth product and the approximation problem. MOS switched-capacitor realizations of basic filter structures are developed. Prep. ECE 3331.

ECE 3617 Active Network Synthesis and Design A (2QH)
Fall Quarter, As Announced
ECE 3617 and ECE 3618 cover the same material with the same prerequisites as ECE 3616, but in two 2QH courses. Prep. ECE 3331.

ECE 3618 Active Network Synthesis and Design B (2QH)
Winter Quarter, As Announced
Continuation of ECE 3617. Prep. ECE 3617.

ECE 3619 Network Synthesis (4QH)
Fall Quarter, As Announced
Matrix circuit analysis including m-port parameter systems. Positive-real functions. Energy functions. Driving-point synthesis techniques for LC, RC, and RL networks. Driving-point synthesis of RLC networks. Properties of two-port networks. Two-port synthesis, including the parallel ladder realization. Lattice synthesis. Prep. BSEE or ECE 3100 and ECE 3101.

ECE 3620 Network Synthesis A (2QH)
Winter Quarter, As Announced
ECE 3620 and ECE 3621 cover the same material with the same prerequisites as ECE 3619, but in two 2QH courses. Prep. ECE 3100 and 3101.

ECE 3621 Network Synthesis B (2QH)
Spring Quarter, As Announced
Continuation of ECE 3620. Prep. ECE 3620.

ECE 3622 Special Topics in Electronics - Analog MOS LSI Circuits (2QH)
Spring Quarter
Selected topics of practical importance in the design of analog MOS integrated circuits. Principal topics are: NMOS & CMOS technology and devices; MOS transistor analog switch; digital - analog converters; comparators; analog - digital converters; sampled analog filtering concepts; switched - capacitor filters. Prep. ECE 3331 and ECE 3384.

ECE 3623 Gate Array Design (4QH)
Fall Quarter
The design, simulation, verification, and implementation of a CMOS gate array. Description of the VAX based gate array design and logic simulator tools. Students will be given design examples of digital logic circuits which will be entered, verified, and simulated. A description of the GE CMOS Macrocell Circuit Library and an introduction to TEGAS Logic Simulator will be included. After the completion of this course the GE Microelectronics Center, at Research Triangle Park, North Carolina, will fabricate the chosen student gate array design projects which then can be tested and evaluated. Prep. ECE 3101 and 3103 or equivalent.

ECE 3624 Gate Array Design - A (2QH)
Winter Quarter
ECE 3624 and ECE 3625 cover the same material with the same prerequisites as ECE 3623, but in two 2QH courses

ECE 3625 Gate Array Design - B (2QH)
Spring Quarter
Continuation of ECE 3624. Prep. ECE 3624.

ECE 3626 Integrated Circuits Fabrication Processes I (4QH)
Spring Quarter
Overview of, and the principles underlying, the basic techniques and processes employed in the fabrication of modern integrated circuits. Topics covered include crystal growth and epitaxy, oxidation deposition, diffusion and ion implementation, and metalization. A discussion of how these processes are combined to yield the current technologies (bipolar, NMOS, CMOS, MESFET) will be undertaken. Prep. ECE 3384.

ECE 3627 Integrated Circuits Fabrication Processes I-A (2QH)
Winter Quarter
ECE 3627 and ECE 3628 cover the same material with the same prerequisites as ECE 3626, but in two 2 QH courses. Prep. ECE 3384.

ECE 3628 Integrated Circuits Fabrication Processes I-B (2QH)
Spring Quarter
Continuation of ECE 3627. Prep. ECE 3627.

ECE 3629 Integrated Circuit Fabrication Processes II (4QH)
Fall Quarter, As Announced
The goal of this course is to provide the student with knowledge of the state of the art microelectronic fabrication techniques. Advance topics include electron beam, ion beam and x-ray lithographic techniques as well as dry processes which include plasma etching, ion beam processes and reactive ion etching. The concept of gas and plasma kinetics will be introduced. The mechanisms of sputtering and plasma etching will be discussed. Future device development and processing requirements will be covered also. Prep. ECE 3626.

ECE 3630 Integrated Circuit Fabrication Processes II-A (2QH)
Fall Quarter, As Announced
ECE 3630 and ECE 3631 cover the same material with the same prerequisites as ECE 3629, but in two 2 QH courses. Prep. ECE 3626.

ECE 3631 Integrated Circuit Fabrication Processes II-B (2QH)
Winter Quarter, As Announced
Continuation of ECE 3630. Prep. 3630.

ECE 3632 Design and Analysis of Digital Integrated Circuits (4QH)
Winter Quarter, As Announced
The analysis and design of basic digital-integrated-circuit logic families are treated. Bipolar circuits, including advanced-Schottky TTL, emitter-coupled logic (ECL). Double-buffered CMOS and NMOS logic gates, including dynamic logic circuits such as domino logic, are covered. Memory cells and basic cells in logic arrays are treated. Design considerations include propagation delay, switching speed, fan-out and the effect of parasitics. Design techniques are correlated with computer simulations. Prep. ECE 3101 or equivalent.

ECE 3633 Design and Analysis of Digital Integrated Circuits A (2QH)
Winter Quarter, As Announced
ECE 3633 and ECE 3634 cover the same material with the same prerequisites as ECE 3622, but in two 2 QH courses. Prep. ECE 3101 or equivalent.

ECE 3634 Design and Analysis of Digital Integrated Circuits B (2QH)
Spring Quarter, As Announced
Continuation of ECE 3633. Prep. ECE 3633.

ECE 3635 Antennas and Radiation (4QH)
Spring Quarter
Fundamental properties of antennas; linear and aperture antennas including slot, horn and patch antennas; arrays; receiving antennas; and numerical methods in antenna analysis. Topics in radiowave propagation; antennas over plane and spherical earth; interference, diffraction, surface waves, ducting; scattering from terrain surfaces; other propagation topics as time permits. Prep. ECE 3341, 3344.

ECE 3636 Antennas and Radiation A (2QH)
Fall Quarter
ECE 3636 and ECE 3637 cover the same material with the same prerequisites as ECE 3635, but in two 2 QH courses. Prep. ECE 3341 and 3344.

ECE 3637 Antennas and Radiation B (2QH)
Winter Quarter
Continuation of ECE 3636. Prep. ECE 3636.

ECE 3638 Microwave Electron Devices (4QH)
Fall Quarter
The fundamental principles and operation of the principle types of conventional (linear-beam and crossed-field) and novel (maser effect) devices will be presented. Interactions of non-relativistic and relativistic electron beams with electromagnetic fields. Linear-beam tubes (klystron, traveling wave tube, backward-wave amplifier and oscillator etc.) crossed-field tubes (magnetron, forward and backward cross-field amplifier, high-gain CFA, etc.). Maser-effect devices (cyclotron maser, gyrotron). Prep. ECE 3341.

ECE 3639 Microwave Electron Devices A (2QH)
Winter Quarter
ECE 3639 and ECE 3640 cover the same material with the same prerequisites as ECE 3638, but in two 2QH courses. Prep. ECE 3341.

ECE 3640 Microwave Electron Devices B (2QH)
Spring Quarter
Continuation of ECE 3639. Prep. ECE 3639.

ECE 3641 Microwave Solid State Devices (4QH)
Winter Quarter
The course will cover the principles of microwave solid state devices. Passive devices to be discussed are varactor diodes and their applications in parametric amplifiers with a discussion of the Manley-Rowe relations, varistors, p-i-n diodes and step recovery diodes. Active two-terminal devices will be covered: the Ridley-Watkins-Hilsum Gunn effect will be discussed followed by its application in transferred electron devices with a description of the different modes of operation; the theory of avalanching and the principle of operation of the Read diode will be discussed followed bya detailed description of IMPATT, TRAPATT, BARRITT and DOVETT devices and their appliations in oscillator and amplifier

circuits. Microwave operation of bipolar and FET devices including the HBT, MESFET and HEMT will be described: the small-signal equivalent circuit model, figures of merit and noise figure analysis. This course should give the student a good understanding of microwave solid state devices and their applications. Prep. ECE 3101 or equivalent.

ECE 3644 Passive Microwave Circuits (4QH)
Fall Quarter
This course covers the characteristics of passive circuits with particular emphasis on planar circuits, since these have bocome significant with the development of MMIC technology. S parameter theory which is fundamental to all microwave circuit analysis will be covered in detail. The characteristics of planar transmission lines, discontinuities, and lumped circuits will be developed. Dielectric and YIG resonators will be treated in detail. Impedance matching will be discussed. Hybrids and couplers, which are important in all microwave circuits will be defined and the corresponding applications covered. Microwave filters and multiplexers will be described. ECE 3101 or equivalent.

ECE 3649 Semiconductor Device Modeling (4QH)
Winter Quarter
An introduction then numerical simulation of semiconductor devices both by matrix solution of the PDEs and the Monte Carlo method. Topics include: Review of pn junction physics and the drift-diffusion model for charge transport. Formulating the equation set and discretizing it on a non-uniform grid. Solution of resulting PDEs by finite difference and finite element methods; sparse matrices; discussion of convergence, error, and tradeoffs. Going beyond the drift-diffusion equations -- the hydrodynamic model. The Boltzman Transport Equation and the Monte Carlo technique. Applications to BJTs. HBTs, MOSFETS, and novel structures. Survey of current research topics. Much hands-on experience through programming assignments. Prep. ECE 1408 or equivalent. Working knowledge of high-level programming language.

ECE 3797 Engineer Degree Thesis Continuation (0QH)
Any Quarter
Candidates to register for thesis continuation if their thesis is not completed after they have registered for three consecutive quarters or ten quarter hours of EE degree thesis. Continuous registration is required until the candidate graduates.

ECE 3880 Doctoral Thesis (0QH)
Any Quarter
Theoretical and/or experimental work conducted under the auspices of the department. Prep. Passing of PhD Qualifying Exam.

ECE 3887 Master's Seminar I (2QH)
Any Quarter
A library survey of a selected topic in the general field of electrical engineering with an oral presentation based on this survey. Participation in the departmental seminar program of guest lectures. Prep. Bachelor of Science degree in Engineering or Science.

ECE 3888 Master's Seminar II (2QH)
Any Quarter
The preparation of a research paper suitable for publication in a professional journal, plus an oral presentation of this report. Prep. ECE 3887.

ECE 3889 Doctoral Seminar (0QH)
Any Quarter
This requirement will be satisfied by the student presenting a seminar to the Electrical Engineering Department on a subject related to his/her PhD thesis. The thesis supervisor will coordinate the seminar. Prep. Passing of PhD Qualifying Exam.

ECE 3892 Doctoral Reading (0QH)
Any Quarter
Material approved by the candidate's advisor. (Only S or F grades will be assigned for this course.) Prep. Passing of PhD Qualifying Exam.

ECE 3893 Special Problems in Electrical Engineering (2QH)
Any Quarter
Theoretical or experimental work under individual faculty supervision. Prep. Consent of Department Chairman. (4QH equivalent is course ECE 3896)

ECE 3894 Engineer Degree Reading (4QH)
Any Quarter
To be taken upon completion of 30 QH of satisfactory course work. No credits towards course re-
quirements is given. Minimum of 4 QH, maximum of 8 QH allowed per quarter.

ECE 3895 Engineer Degree Reading (8QH)
Any Quarter

ECE 3896 Special Problems in Electrical Engineering (4QH)
Any Quarter

DEPARTMENT OF INDUSTRIAL ENGINEERING AND INFORMATION SYSTEMS

The Department of Industrial Engineering and Information Systems offers the following graduate degrees: Master of Science in Industrial Engineering (MSIE); Master of Science in Engineering Management (MSEM); Master of Science in Information Systems (MSIS); Industrial Engineer; and Doctor of Philosophy. The department is also the major contributor to the Engineering Software Design concentration of the interdisciplinary Computer Systems Engineering degree (see Computer Systems Engineering Section of this catalog). Students pursuing a Master of Science in Industrial Engineering or Engineering Management may follow a general program with no concentration or choose one of the following areas of concentration: Computer and Information Systems; Manufacturing Systems; Operations Research; or Quality Control and Reliability Analysis.

The MSIE and MSEM programs may be taken by full-time students on a continuous basis or under the cooperative education plan. These programs may also be pursued on a part-time basis, with courses being offered in the evening.

The MSIS program may be pursued by students who are currently employed in the information systems profession on a part-time or full-time basis, all other applicants are expected to enroll as full-time students for two or three quarters. Then they may participate in the graduate cooperative education program by taking a position in information systems for a minimum of six months. During this time, candidates may continue to take courses in the evening graduate program to further meet the degree requirements.

Master of Science Degree Requirements for MSIE and MSEM

A minimum of 40 quarter hours of graduate level credit is required for the MSIE and MSEM master's degree programs.

Up to six quarter hours may be elected in other graduate schools within Northeastern University with the approval of the student's faculty advisor and the Director of the Graduate School offering the desired course. The amount of credit applied toward the degree will be established by the student's advisor.

Students accepted into the MSIE or MSEM programs must have a Bachelor of Science degree in engineering, science, or equivalent. Knowledge of a higher level computer language is a prerequisite.

Master of Science in Industrial Engineering

The MSIE degree requires either an eight quarter hour thesis or a four quarter hour special project. Arrangements for and approval of the topic for the special project or thesis must be made with a member of the full-time faculty of the department. All MSIE students must take the core courses shown below. Equivalent substitutions must be approved by a petition.

	With Thesis	With Project
Core Courses	24 QH	24 QH
Electives	8 QH	12 QH
Thesis or Project	8 QH	4 QH
Minimum Quarter Hours Required	40 QH	40 QH

Required Core Courses

		Credits
IIS 3113	Basic Probability and Statistics	4
IIS 3215	Engineering Economy	4
IIS 3304	Production Analysis	4
IIS 3503	Simulation Methodology and Applications	4
IIS 3523	Applied Statistics	4
IIS 3530	Operations Research I	4

The remaining coursework is satisfied by elective courses. A student may opt for a concentration in Computers and Information Systems, Manufacturing Systems, Operations Research, or Quality Control and Reliability Analysis by taking the required courses for the elective concentration.

Master of Science in Engineering Management

The core course requirements for the Engineering Management program are listed below:

Core Courses	24 QH
Electives	16 QH
Minimum Quarter Hours Required	40 QH

Required Core Courses

		Credits
IIS 3113	Basic Probability and Statistics	4
IIS 3207	Financial Management	4
IIS 3215	Engineering Economy	4
IIS 3217	Engineering Project Management	4
IIS 3523	Applied Statistics	4
IIS 3530	Operations Research I	4

The remaining coursework is satisfied by elective courses. A student may opt for a concentration in Computers and Information Systems, Manufacturing Systems, Operations Research, or Quality Control and Reliability Analysis by taking the required courses for the elective concentration.

Courses for Elective Concentrations*

Computers and Information Systems

		Credits
IIS 3604	Data Structures	4
IIS 3615	Analysis & Design of Computer Information Systems	4
IIS 3628	Data Base Management Systems	4

Manufacturing Systems

IIS 3309	Computer Methods in Manufacturing	4
IIS 3310	Manufacturing Methods and Processes	4
IIS 3311	Computer-Aided Manufacturing	4

Operations Research (Any three of the following courses) *

IIS 3503	Simulation Methodology	4
IIS 3524	Multi-Criteria Decision Making	4
IIS 3531	Operations Research II	4
IIS 3532	Operations Research III	4

Quality Control and Reliability Analysis

IIS 3516	Statistical Quality Control	4
IIS 3525	Intro. to Reliability and Risk Assessment	4
IIS 3535	Reliability Engineering & Testing	4

* Concentration electives are 12 quarter hours

Master of Science in Information Systems

The program consists of courses which help students develop both management and information technology skills. The prerequisite set of courses (totaling 18 credits) will be required for students, or waived, depending on their particular academic background and undergraduate experience. It is expected that students beginning this program will have an adequate background in the following areas: calculus, probability, accounting, and programming languages (including Pascal, COBOL and an Assembly Language). Deficiencies in this background are remedied by taking the appropriate prerequisite courses described below.

Based upon the recommendation of the Graduate School and the advisor, a student may be required to take all or some of the following prerequisite courses. However, no more than six hours of graduate credit from the prerequisite courses can be applied to the minimum degree requirements of forty-four quarter hours. Students must obtain advisor approval for selection of MSIS and other electives.

Up to six quarter hours may be elected in other graduate schools within Northeastern University with the approval of the student's faculty advisor and the Director of the Graduate School offering the desired course. The amount of credit applied toward the degree will be established by the student's advisor.

MSIS Prerequisite Courses

MTH 3211 Elements of Math for Info Sys I 2
(Functions, Matrices & Counting/Probability Concepts)
MTH 3212 Elements of Math for Info Sys II 2
(Discrete Structures)
MTH 3213 Elements of Math for Info Sys III 2
(Basic Differential & Integral Calculus)
MTH 3214 Elements of Math for InfoSys IV 2
(Basic Probability & Statistics)
IIS 3110 Pascal for Information Systems 4
IIS 3111 Principles of COBOL 2
IIS 3116 Assembly Language 4

Course Requirements

Core Courses	28	QH
MSIS Elective Courses	8	QH
Open Electives	8	QH
Minimum Quarter Hours Required*	44	QH

*includes a maximum of 6 QH of prerequisite courses

MSIS Core Courses-28 QH

IIS 3604 Data Structures 4
IIS 3607 Operating Systems & Systems Software 4
IIS 3610 Computer Architecture 4
IIS 3615 Analysis and Design of Computer Info Sys 4
IIS 3622 IS in a Microcomputer Environment 4
IIS 3628 Data Base Management Systems 4
IIS 3632 C/UNIX for Information Systems 4

MSIS Elective Courses-Select 8 QH*

IIS 3113	Basic Probability and Statistics	4
IIS 3217	Engineering Project Management	4
IIS 3218	Planning & Management Information Sys Dev	4
IIS 3523	Applied Statistics	4
IIS 3530	Operations Research I	4
IIS 3531	Operations Research II	4
IIS 3601	Compiler Design	4
IIS 3623	File Processing	2
IIS 3624	Software Engineering	4
IIS 3629	Expert Systems in Engineering	4
IIS 3630	Machine Intelligence	4
IIS 3637	Programming Languages for Software Engineering	4

*MSIS elective courses may also include IIS courses numbered IIS 33XX or higher or contain Computer Science and Business College courses (with approval of academic advisor).

The Industrial Engineer Degree

Objective

This degree is designed for those who wish to undertake graduate study beyond the Master of Science degree which is less extensive and more applied than that required for the doctorate. The program leading to the Industrial Engineer degree permits a candidate to pursue a course of study at the upper graduate level which will help the student develop in-depth knowledge in selected Industrial Engineering techniques and the ability to apply these techniques to complex problems in a real-world setting.

Course Requirements

A minimum of 40 quarter hours beyond the Master of Science degree is required. Normally ten quarter hours of credit out of the 40 will be granted for work on the Industrial Engineering degree project. A minimum of 20 quarter hours must be taken in Industrial Engineering.

Engineer Degree Project

To be awarded the degree of Industrial Engineer, the candidate must complete, in addition to the required course work, a project demonstrating a high level of competence in structuring and solving a complex engineering problem. The problem addressed in this project is of an applied nature. Where applicable, an on-going organization will be used as the setting. The work should lead to a solution which satisfies all technological and organizational constraints, and is therefore capable of being implemented. The topic will be selected by the student and the faculty advisor. Normally, a project committee of three faculty members will be appointed. A final oral examination for defense of the written report of the Industrial Engineer degree project conducted by the student's project committee is also a requirement for the degree.

Residence Requirement

Since the Industrial Engineer degree project requires the structuring and solving of a complex problem, residence requirements will be satisfied by an arrangement, approved by the advisor, which allows the student to devote a sufficient portion of his or her time to the project to permit an intensive problem-solving experience.

The Doctor of Philosophy Degree

Objectives

The Ph.D. program provides education at the leading edge of a field of knowledge. Its intent is to prepare an individual to do research aimed at expanding the knowledge of the field and to teach advanced topics in that area. While doctoral education is broadly-based, it is also characterized by in-depth study in a selected specialty. This involves the development of the ability to evaluate and understand current research literature. Doctoral education goes beyond the mastery of standard problem-solving techniques and is intended to prepare an individual for sustained independent research and intellectual development.

Admission Requirements

Individuals seeking admission to the Ph.D.. program should have a background that indicates outstanding potential for the successful completion of the program and for making substantive contributions to the field. Students entering the Ph.D. program who do not hold a Master's degree may elect to obtain this degree as part of their Ph.D. program.

Programs of Study

Each Ph.D. student will have an advising committee appointed by the Chairman of the Graduate Committee. This committee will consist of an academic advisor plus two other IE/IS faculty members. During the first quarter of residency, the student and his/her advisor will prepare a proposed program of study. This committee will also assist in evaluating and approving the student's readiness to take the Ph.D. qualifying exam.

Although there are no fixed course requirements for the Ph.D. degree, a doctoral program for student with no prior graduate work will normally consist of approximately 80 quarter hours of course work beyond the baccalaureate. Most of this work will usually be in one of the Ph.D. specialties supported by the department: Applied Statistics, Computer Systems Engineering, Manufacturing Systems, and Operations Research. Interdisciplinary programs, such as Man-Machine Systems are also available.

In addition to course work in a major specialty, at least 12 quarter hours of course work are required in a minor field outside of the department. Upon successful completion of the PhD qualifying examination and the majority of required coursework, the student is required to register in three consecutive quarters for IIS 3885 (Dissertation). Upon completion of this sequence, the student is required to register for IIS 3799 (PhD Continuation) in every quarter until the dissertation has been completed. Students may not register for continuation until the three-quarter thesis sequence has been fulfilled.

Qualifying and Comprehensive Examinations

To evaluate the student's potential for completing the Ph.D. program, the department gives a qualifying examination. The Qualifying Examination is a written and oral examination

based on the fundamentals contained in the equivalent of the core courses as specified in the Ph.D. specialties. The student is expected to take this examination after completion of approximately 36 quarter hours of course work.

The Qualifying Examination is described in a separate document available through the Department of Industrial Engineering and Information Systems. The comprehensive examination takes the form of the successful defense of a research proposal.

Doctoral Dissertation Committee and Defense

The focus of the Ph.D. program is on research aimed at expanding the knowledge in the chosen major. Upon selecting a research area and identifying a dissertation advisor from the faculty, the student is expected to prepare a research proposal and suggest membership for the Dissertation Advisory Committee. This advisory committee will consist of four members: dissertation advisor, two other IE/IS faculty members, and a faculty member from outside of the department.

After preparing a research proposal, the student is expected to present it, along with an oral presentation, to the Dissertation Advisory Committee for approval. When the student completes a dissertation that is acceptable to the Dissertation Advisory committee, the student's advisor will schedule a Final Doctoral Examination.

The Final Doctoral Examination will be an oral examination on the research area and the results obtained. The student will pass with a simple majority vote. A vote may be favorable subject to minor revisions in the dissertation; these would be coordinated by the advisor. The committee will communicate the vote to the Director of the Graduate School of Engineering.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work or two consecutive years of part-time graduate work. In the latter case, a detailed time schedule must be approved by the students' advisor to ensure that the time being devoted to graduate work is sufficient.

Specialty Areas

1. Applied Statistics
2. Computer Systems Engineering
3. Man-Machine Systems
4. Manufacturing Systems
5. Operations Research

The program of study in each specialty area consist of a set of required core courses at the first year of graduate study (Master's level courses), a set of second year graduate electives within the specialty, and a set of capstone (research oriented) courses. In addition, the programs must have an appropriate minor of at least 12 quarter hours of course work outside the IE/IS department that supports the specialization. Students who have completed appropriate graduate course work in their chosen specialty areas at other institutions will be given credit for this work and will be given advanced standing in their programs of study.

Faculty

Stuart J. Deutsch, Chairman

Professors

Cullinane, Thomas P., PhD, Virginia Polytechnic and State University; manufacturing systems, facilities planning, project management

Deutsch, Stuart J., PhD, University of Wisconsin; manufacturing systems, quality engineering, process of optimization

Freeman, David R., PhD, Stanford University; engineering economy, computer-aided manufacturing

Heising, Carolyn D., PhD, Stanford University; reliability analysis, probabilistic risk assessment

Mourant, Ronald R., PhD, Ohio State University; simulation, human-computer interaction

Rule, Wilfred P., MS, Massachusetts Institute of Technology; management information systems

Associate Professors

Fard, Nassar, PhD, University of Arizona; reliability analysis

Goldman, David, MS, Northeastern University; manufacturing systems

Gupta, Surendra M., PhD, Purdue University; simulation, operations research, production systems

Hulbert, Thomas E., MS, Northeastern University; production engineering, manufacturing systems

Kokar, Mieczyslaw, PhD, Technical University of Wroclaw; artificial intelligence, operating systems

Melachrinoudis, Emanuel S., PhD, University of Massachusetts; operations research, manufacturing systems

Perry, Ronald F., PhD, University of Michigan; simulation, management information systems

Voland, Gerard G.S., PhD, Tufts University; engineering design, control theory, rehabilitation engineering

Wang, C.C., PhD, Georgia Institute of Technology; robotics, machine vision, manufacturing systems, engineering statistics

Assistant Professors

Brennan, Louis, PhD, University of Manchester; human factors, simulation, manufacturing

Helander, Mary, PhD, State University of New York, Buffalo; operations research, production systems and computer systems

Kim, Jason J., PhD, University of Tennessee; simulation, manufacturing systems, expert systems

Maddox, Anthony, PhD, University of Illinois - Urbana; artificial intelligence, computer perception

Advisors

MSIE & MSEM: Profs. Brennan, Cullinane, Fard, Goldman, Gupta, Heising, Helander, Kim, Melachrinoudis and Wang

MSCSE: Profs. Kokar, Maddox, Mourant, Rule and Voland

MSIS: Prof. Perry

PhD: Prof. Deutsch

INDUSTRIAL ENGINEERING

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time. Burlington campus offerings are designated as *.

IIS 3110 Pascal for Information Systems (4QH)
Fall Quarter
An introductory course using the Pascal programming language. The topics include: algorithms and structured programming; primitive data types; control constructs; subprograms; compound data types (arrays,records); recursion; abstract data-types; input/output processing; pointers, and object-oriented programming. Prep. Admission to Graduate Program.

IIS 3111 Principles of COBOL (2QH)
Fall Quarter
Fundamentals of computer programming in COBOL. Topics include elementary computer functioning, program organization, input/output
operations, arithmetic and data-handling verbs, and program logic development through the use of flow charts. Storage and manipulation of large data files on magnetic tape are introduced. No prior computer experience is required. Prep. Admission to Graduate Program.

IIS 3113 Basic Probability and Statistics (4QH)
Fall and Winter* Quarters
Fundamental concepts of probability. Events, sample space, discrete and continuous random variables. Density functions, mass functions, cumulative probability distributions and moment generating functions. Expectation of random variables. Common discrete and continuous probability distributions including binomial, Poisson, geometric, uniform, exponential and normal. Multivariate probability distributions, covariance and independence of random variables. Sampling and descriptive statistics. Parameter estimation, confidence intervals and hypothesis testing. Prep. Admission to Graduate Program.

IS 3116 Assembly Language (4QH)
Winter Quarter
The study of assembly language programming with emphasis upon understanding computer organization. Instruction types, formats, and addressing modes are considered in detail at both the symbolic and machine levels. Register organization, binary data and number representations, and two's complement arithmetic are studied. Many assembly language programs are written and debugged, providing an understanding of structured programming constructs, data structure organization, passing parameters on the stack, macros, instruction timing, interrupt handling, interfacing with devices, system utilities and higher-level languages. Possible computers include Motorola 6800, Intel 80386-based machines, or the VAX. Prep. Higher level language.

IIS 3204 Engineering/Organizational Psychology (4QH)
Fall and Spring* Quarters
An analysis of the purpose and functioning of organizations as the basic networks for achieving goals through coordination of effort, communication, and responsibility. The role and function of engineering organizations based on modern behavioral science concepts. The application of psychology to industry relative to human relations, group dynamics, tests and measurements, personnel practices, training, and motivation. Prep. Admission to Graduate Program.

IIS 3207 Financial Management for Engineers (4QH)
Winter and Spring* Quarters
Study of the issues and processes of short-term financing on industrial firms; financial analysis of cases, supplemented by readings to develop familiarity with sources and uses of working

capital as well as the goals and problems involved in its management. Also covered is the analysis necessary for such long-term financial decisions as issuance of stock or bonds; contracting of leases or loans, and financing of a new enterprise; mergers, capital budgeting, the cost of capital, and the valuation of a business. Prep. Admission to graduate program.

IIS 3215 Engineering Economy (4QH)
Winter Quarter
Economic modeling and analysis techniques for selecting alternatives from potential solution to an engineering problem are explored. Measures of merit such as present worth, annual worth, rate of return, and benefit/cost techniques are considerded. Recent techniques of economic analysis especially the tools of decision making will be examined. Decisions under uncertainty are explored. Prep. Admission to graduate program.

IIS 3217 Engineering Project Management (4QH)
Fall and Winter* Quarters
The optimization of schedules utilizing pertinent software tools such as the linear programming and project management packages will be undertaken. Other graphics software used to draw project diagrams such as Gantt charts, PERT diagrams, manpower loading charts and funding charts will be included. Determination of the critical path and comparison of actual performance with the planned schedule will be covered. The systems life cycle will be considered. Needs analysis, requirements definition, preliminary design, detailed design and implementation will be addressed in the context of project management. Prep. Admission to Graduate Program.

IIS 3218 Planning and Managing Information Systems Development (4QH)
Winter Quarter
The computer system development life cycle. Interactions between the system and the organization. Design parameters and tradeoffs. Planning for externalities. Individual and organizational aspects of human decision making. Systems approach to planning, management and control of effective information systems development. The course will be based on extensive use of case studies and will include some guest speakers. Prep. IIS 3615.

IIS 3304 Production Analysis (4QH)
Spring Quarter
Modern quantitative techniques of production planning and control considering deterministic and probabilistic models are presented. Topics include project planning, forecasting, aggregate planning and master scheduling, inventory analysis and control, materials requirement planning, job shop scheduling and dispatching problems. Prep. IIS 3113 and IIS 3530.

IIS 3309 Computer Methods in Manufacturing (4QH)
Spring Quarter
In depth coverage of the use of computers in the system design and implementation of Computer Integrated Manufacturing (CIM) is presented. Possible topic areas are the ICAM definition language for modeling process, MRP, project management, manufacturing simulation and facility layout, CAD/CAM, database interface, and other important application of computers to manufacturing systems. Prep. IIS 3311, IIS 3503, or by permission of instructor.

IIS 3310 Manufacturing Methods and Processes (4QH)
Fall Quarter
The structures of polymers (thermoplastic, thermosetting and glasses). Manufacturing processes for polymers including thermoforming are included. Structure of metals, the manufacturing processes for metal forming are presented. Alloys and welding and brazing are also included. Prep. Bachelor of Science degree in Engineering or Science.

IIS 3311 Computer-Aided Manufacturing (4QH)
Winter Quarter
A first course (overview) of computer aided manufacturing. Covers the areas that encompass the term CAM, i.e., group technology, material requirements planning, part coding and classification, numerical control, part programming and management systems. Broad coverage of each of the areas is given to allow the student to gain an appreciation of the coming review of the automated factory. Prep. Higher level language.

IIS 3312 Production and Inventory Systems (4QH)
Spring Quarter
Econometric methods of forecasting the demand for industrial products; emphasis on techniques applicable to individual companies and the total demand. The principal tool used is the mathematical model of the causal factors with special attention to determining the reliability of the model. The design and operation of inventory systems from a scientific management point of view, including both required theory and practical aspects. Subjects include inventory control models and techniques, production planning and control models and methods. Prep. IIS 3523 and IIS 3530.

IIS 3313 Inventory Theory (4QH)
Fall Quarter
This course considers the nature and characteristics of inventory systems. It is concerned with techniques of constructing and analyzing mathematical models of inventory systems with a view towards determining operating policies for such systems. Prep. IIS 3113 and IIS 3530.

IIS 3314 Logistics, Warehousing, and Scheduling (4QH)
Winter Quarter
The determination of needs and requirements for logistics within large-scale systems and business environments are explored. Measures of logistics including reliability, maintainability, and supportability are examined. Systems maintenance concepts, logistics support analysis, and logistics in system design are covered. Warehousing and scheduling in the context of a business logistics system are introduced. Approaches to examining warehouses and the associated algorithms are considered. Prep. IIS 3113.

IIS 3400 Human Factors Engineering (4QH)
Fall Quarter
Sensory motor and work environment considerations. Topics include the design of equipment and systems for human use, with the application of engineering psychology; visual and auditory presentation of information; human information processing and skilled task performance. The human as a work-performing, heat generating physiological engine, and the implied restrictions on the equipment and work place to provide occupational safety and effective man/machine performance. Prep. Admission to graduate school.

IIS 3406 Man-Computer Interaction (2QH)
As Announced
Design and evaluation of the man-computer interface in on-line information systems; formatting of visual displays and auditory outputs, techniques to facilitate operator inputs, pacing and control of the interactive sequence, operator training, task analysis and performance testing. Student projects in areas of novel application. Prep. Admission to graduate school.

IIS 3503 Simulation Methodology and Applications (4QH)
Fall* and Spring Quarters
Covers when, where and how to use discrete event simulation techniques. Topics include model design, development and validation; tactical and strategic planning considerations in the use of the model; input data reduction; alternative programming languages for implementing models; efficiency in running simulations, and statistical reliability in the design and analysis of simulation experiments. Several special purpose simulation languages are discussed, e.g. SIMSCRIPT, GPSS, and SIMAN. The opportunity to code models in one language is provided. Prep. IIS 3523 and higher level language.

IIS 3505 Advanced Simulation Analysis (4QH)
Spring Quarter
The focus of this course is the statistically-based methodology of simulation analysis. Topics covered include: selection of input probability distributions, random number and random variate generation, analysis of output streams, variance reduction techniques and experimental design and optimization. We seek a thorough understanding of the theory underlying these issues and how they relate to the design and execution of statistically valid simulation studies. The level of discussion is state-of-the-art as defined by the latest published research results. In light of this background, an assessment of the effectiveness with which these issues are included in the major simulation languages (e.g., SIMAN, GPSS, SIMSCRIPT) is made. Prep. IIS 3503, Simulation Methodology and Applications.

IIS 3509 Design of Experiments (4QH)
Spring Quarter
Theory and application of experimental design techniques such as modeling and statistics which can optimize resources and improve decision making risks. This course will cover experiments with single and multiple factors of interest and consider experiments with high order experimental restrictions. Some additional analysis techniques will also be covered. Prep. IIS 3523.

IIS 3513 Network Analysis and Advanced Linear Programming (4QH)
Winter Quarter
Concepts of network analysis and advanced linear programming are considered. Topics include spanning trees, path and flow algorithms, matchings and coverings, postman and traveling salesman problem, location problems, revised simplex and polynomial bounded algorithms, parametric programming and concepts of upper bounding and decomposition. Prep. IIS 3530.

IIS 3515 Queuing Theory (4QH)
Winter Quarter
Development of stochastic techniques used in queueing theory. Single and multiple server queues. Truncated queues. Complementarity and equivalence in queues. Queueing networks. Emphasis will be placed on theory as well as applications. Prep. IIS 3531.

IIS 3516 Statistical Quality Control (4QH)
Spring Quarter
This course is designed to study the fundamental concepts of quality planning, and improvements. Analysis and application of modern statistical process control methods, inspection error, and design of sampling plans will be given. Topics also include: software quality assurance, and study of the concepts of Deming, Ishikawa, Feigenbum, and Taguchi's approach in quality planning, organization, and improvement. Prep. IIS 3113.

IIS 3522 Systems Engineering Design and Analysis (4QH)
Spring Quarter
Principles of systems modeling and analysis using continuous simulation techniques. Topics include differential equations as system models; Laplace transformations;numerical approximation techniques; stability; steady-state error; control actions; alternative modeling schemes; and validation of system models via continuous simulation techniques. Prep. Admission to graduate school and higher level language.

IIS 3523 Applied Statistics (4QH)
Fall* and Winter Quarters
This course develops statistical models for analysis and prediction of random phenomena. Topics include: review of descriptive statistics and hypothesis testing; linear models, both regression and ANOVA; chi-squared and non-parametric tests; and introduction to design of experiments. Emphasis will be placed on applying linear models in real life situations. Prep. IIS 3113.

IIS 3524 Multi-Criteria Decision Making (4QH)
Spring Quarter
Theory, computation and applications of multicriteria decision making. Topics include techniques for generating noninferior solutions, techniques for finding the best-compromise solution, multiattribute utility functions, goal programming and multiple decision-maker methods. Prep. IIS 3530.

IIS 3525 Introduction to Reliability Analysis and Risk Assessment (4QH)
Fall Quarter
Introduction to probability theory, classical and Bayesian statistics useful for reliability analysis of large, complex systems. Bayesian probability encoding of experience data; principles of the methods of risk assessment and reliability analysis including fault trees, decision trees, and reliability block diagrams. Practical applications to industrial operations, e.g., nuclear and chemical plants, military systems, large processing plants, are treated. Prep. IIS 3113 or permission of instructor.

IIS 3526 Advanced Reliability Analysis, Risk Assessment, and Maintenance (4QH)
Winter Quarter
Extended application and use of reliability and probabilistic risk analysis methods. Methods for common cause/dependent failure analysis, human reliability analysis, and treatment of uncer-

tainties. Bayesian statistics applied to data analysis and discrete probability distribution (DPD) arithmetic for propagation of uncertainty. Time dependent reliability analysis, Markov models, availability, and maintenance theory. Replacement and maintenance strategy development. The role of maintenance in improving systems reliability, performance, and productivity. The Deming method of quality control. Case studies in industrial system. Prep. IIS 3525.

IIS 3530 Operations Research I (4QH)
Fall and Summer* Quarters
Introduction to the theory and use of deterministic models to represent industrial operations. It includes linear programming and networks. Prep. Course in linear algebra.

IIS 3531 Operations Research II (4QH)
Fall* and Winter Quarters
Introduction to theory and use of stochastic models to represent industrial operations. It includes dynamic programming, Markovian models, queueing, and inventory models. Prep. IIS 3113.

IIS 3532 Operations Research III (4QH)
Spring Quarter
Important families of mathematical programming problems and optimization methods will be covered. The cutting plane and the branch and bound algorithm for binary and mixed integer programming problems. Introduction to nonlinear programming including unconstrained optimization, the Kuhn-Tucker conditions, gradient methods, separable, quadratic and geometric programming. Prep. IIS 3530.

IIS 3535 Reliability Engineering and Testing (4QH)
Spring Quarter
This course is intended to acquaint the students with the evolving methodology of reliability as a design parameter. The problems of quantifying, assessing and verifying reliability are studied. Various factors that determine the stress and strength of components and their impact on system reliability are presented. Practical applications, examples, and problems cover a broad range of engineering fields, such as mechanical, electrical, industrial, computer, structures and automatic control systems. Prep. IIS 3113.

IIS 3540 Total Quality Control for Engineering (4QH)
As Announced
Principles of Total Quality Control (TQC). Japanese management methods for technologies: manufacturing, electrical, steel, and automobile industries. Seven statistical methods of TQC: histograms, cause and effect diagrams, check sheets, Pareto diagrams, graphs, control charts, and scatter diagrams. Case studies of TQC implementation in technology management. Guest lectures by invited authorities. Prep. IIS 3113.

IIS 3601 Compiler Design (4QH)
As Announced
An introduction to the principles and techniques used in writing compilers. Topics include lexical analysis, parsing, semantic analysis, code generation, and symbol table management. Projects and homework in the C language. Prep. C language programming experience.

IIS 3604 Data Structures (4QH)
Fall, Winter and Spring* Quarters
An introduction to basic concepts of data structures. Topics include arrays, stacks, lists, linked lists, queues, trees, graphs, symbol and hash tables, and files. An abstract data type for each data structure is presented and various implementations in a high level language are discussed. Algorithms for handling data are analyzed. Applications of particular structures are shown in order to emphasize abstraction in problem solving with computers. Searching and sorting techniques are also covered. Prep. IIS 3110.

IIS 3607 Operating Systems and Systems Software (4QH)
Winter* and Spring Quarters
An exploration of the underlying algorithms and policies which influence the development and execution of modern operating systems. Consideration will be given to operating systems facilities which assist the design and implementation of application programs. The topics include process concurrency, synchronization, deadlock, multiprogramming, virtual memory, pro-

cess scheduling, security, and protection. The UNIX operating system will be used as a model with several programming assignments using UNIX system calls. Prep. C or Pascal and IIS 3604 and IIS 3610.

IIS 3610 Computer Architecture (4QH)
Winter, Spring and Spring* Quarters
Fundamental concepts in computer architecture and organization are investigated. Topics include the history and evolution of computers; digital logic, gating, timing diagrams, and control signals; interconnection structures such as buses and data paths; data storage devices, interfaces, and organization; I/O devices and technology; interrupts and DMA; and cache and paging. An emphasis is placed upon CPU architecture, including binary arithmetic and organization of the ALU, instruction types, formats, addressing modes, and pipelining. Microprogramming of the CPU's control unit is considered in detail, and RISC architectures are surveyed. Prep. IIS 3116.

IIS 3615 Analysis and Design of Computer Information Systems (4QH)
Fall and Winter* Quarters
Introduction to software engineering analysis and design techniques and computer technology. Topics covered include: techniques for determining information requirements for MIS/DSSs; development of the functional systems design; and computer system design considerations such as the CPU, main memory, operating systems functions, computer languages, input devices, secondary memory, file organization, database management systems, data communications, data security, and output and display devices. The main objective of the course is to develop capability in the skeletal design of a computer system to support a given set of information requirements. Prep. Admission to Graduate Program.

IIS 3622 Information Systems in a Microcomputer Environment (4QH)
Winter and Spring* Quarters
The contribution of microcomputers to the implementation of comprehensive decision support systems. The IBM PC, or compatible machine, is used as a representative microcomputer. Detailed examination of the aspects of microcomputer architecture essential to the understanding of this contribution is provided. Topics include: PC architecture, PC operating system, the use of interrupts, data communications and approaches to the rational design and selection of software for PCs. Assignments using the PCs are used to develop insight into the operation of the PC at its lowest level and to experience and evaluate generic categories of PC software. Prep. IIS 3615.

IIS 3623 File Processing (2QH)
As Announced
Processing of sequential, indexed-sequential, and direct/relative data files on tape and disk; record blocking, searching, sorting, and merging operations; random access techniques; introduction to data base management concepts, and if time permits an introduction to RPG. Prep. IIS 3111 or knowledge of COBOL Programming.

IIS 3624 (ECE 3311) Software Engineering (4QH)
Fall and Spring* Quarters
A study of the software life cycle (requirements analysis and specification, software design, coding, testing, and maintenance). Verification, validation and documentation at various stages of the life cycle. Coverage of structured analysis and object-oriented design methodologies. Overviews of user interface design, prototyping, CASE tools, software metrics, and software development environments. Emphasis on modular software construction and development of modular libraries. Course requirements include a small software development project. Prep. higher level language.

IIS 3626 Networks and Telecommunications (4QH)
As Announced
Network goals and applications; architecture, topologies, and protocols; layered communications protocol design; layer functions, interlayer interfaces, and peer processes; performance measures; data communication techniques; wide area and local networks; channel interfaces and access schemes; workstations and server nodes; distributed systems; internetworking. Prep. IIS 3610.

IIS 3628 Data Base Management Systems (4QH)
Fall* and Spring Quarters
Fundamental concepts and design of data base management systems (DBMS). Topics include the role of DBMS in organizations; alternative data base models - hierarchical, network and relational; underlying data structures for each data base model; example DBMS for each model type; design of an information system using a DBMS approach; practical experience with at least one DBMS on a microcomputer or minicomputer, such as RBase 5000 or Data-Trieve. Prep. IIS 3604.

IIS 3629 Expert Systems in Engineering (4QH)
Spring Quarter
An introduction to the theory, topics and applications of expert systems in engineering. Topics include knowledge representation (semantic networks, frames, production rules, logic systems), problem solving methods (heuristic search algorithms, forward and backward chaining, constraint handling, truth maintenance), approximate reasoning methods (Bayesian, Dempster-Shafer, fuzzy logic, certainty factors), expert system project management and knowledge engineering, expert system shells. Development of an expert system for engineering using an expert system shell is part of the course requirements. Prep. Admission to graduate program.

IIS 3630 Machine Intelligence (4QH)
Spring Quarter
This course deals with the area of intelligent computer systems, i.e., such that exhibit some behavior normally attributed to humans - solving problems, reasoning, learning, handling collections of expert knowledge. This course focuses on methods, techniques and implementations of computer systems for problem solving in the area of engineering. Topics include an overview of the field of artificial intelligence (AI), one of the AI programming languages (LISP or Prolog), knowledge representation formalisms and their implementations, search strategies and algorithms, planning, logic and theorem proving, constraint handling and truth maintenance systems, reasoning with uncertainty and heuristics, qualitative reasoning, and applications of artificial intelligence in engineering. Prep. IIS 3604.

IIS 3631 Machine Learning (4QH)
Fall Quarter
This course introduces the students to the problem of developing programs that can learn (i.e., increment their knowledge in the process of execution). It covers some basic principles, techniques, tools and algorithms for building learning systems. The course concentrates on the methods of implementation of the learning algorithms in software rather than on the human learning mechanisms. Classification of machine learning methodology, algorithms and programs is discussed. Current research being conducted in the field of machine learning at various institutions throughout the world is presented. Prep. IIS 3630 - Introduction to Machine Intelligence, or equivalent.

IIS 3632 C/UNIX for Information Systems (4QH)
Spring Quarter
Covers both the fundamentals of programming in C and using the Unix operating system. C topics include: C operators and precedence, functions, C structures and data structures, and program control statements. Unix topics include: basic Unix commands, pipes, filters, Unix file system and shell programming. Major course project: information system coded in C. Prep. IIS 3110 or equivalent.

IIS 3637 Programming Languages for Software Engineering (4 QH)
Spring Quarter
An introduction to programming languages is presented through a consideration of available procedural languages and of the principles of their design and implementation. Languages are surveyed historically, and insight is provided into aspects of programming languages such as control structures, parameter passing conventions, run-time structures, and binding time. Exposure to
modern representative languages is given, including limited hands-on experience with block-structure languages, object-oriented languages, and languages for list processing and logic programming. Prep. IIS 3604.

IIS 3652 Software Engineering Project I (4QH)
Spring Quarter
Team work under faculty supervision on a large

software project. The projects are drawn from an engineering field, design, systems engineering, manufacturing, planning maintenance, reliability, quality control, risk assessment, project control, evaluation of alternatives, etc. The project may cover either the whole software development life cycle or a significant part of it. Prep. IIS 3624, permission of instructor.

IIS 3653 Software Engineering Project II (4QH)
Summer Quarter
Same course description as IIS 3652.

IIS 3797 Engineer Degree Continuation (0QH)
Any Quarter

IIS 3798 Master's Continuation (0QH)
Any Quarter

IIS 3799 PhD Continuation (0QH)
Any Quarter

IIS 3801 Independent Study in Industrial Engineering (2QH)
Any Quarter
Individual work under faculty supervision. Prep. Consent of advisor.

IIS 3802 Independent Study in Industrial Engineering (4QH)
Any Quarter
Same as IIS 3801.

IIS 3804 Special Topics (4QH)
Any Quarter
Special Topics in IE and IS. Prep. Permission of Instructor.

IIS 3806 Seminar in Industrial Engineering (2QH)
Any Quarter
Discussion and presentations of thesis related topics by students , presentations and discussions by faculty and eminent people in the field on timely industrial engineering topics. Field trips and visitations included where appropriate. Prep. Permission of instructor.

IIS 3840 Thesis (Master's Degree) Engineering Software Design (8QH)
Any Quarter
Analytical and/or experimental work in the field of Engineering Software Design conducted under the auspices of the faculty advisor. Prep. Consent of advisor.

IIS 3841 Thesis (Master's Degree) Engineering Software Design (4QH)
Analytical and/or experimental work in the field of Engineering Software Design conducted under the auspices of the faculty advisor. Prep. Consent of advisor.

IIS 3842 Thesis (Master's Degree) Engineering Software Design (2QH)
Analytical and/or experimental work in the field of Engineering Software Design conducted under the auspices of the faculty advisor. Prep. Consent of advisor.

IIS 3850 IE Master's Degree Project (4QH)
Prep. Consent of advisor.

IIS 3860 Thesis (Master's Degree) (8QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the Department. Prep. Consent of advisor.

IIS 3861 Thesis (Master's Degree) (4QH)
Any Quarter
Same as IIS 3860.

IIS 3862 Thesis (Master's Degree) (2QH)
Any Quarter
Same as IIS 3860.

IIS 3870 Industrial Engineer Degree Project (10QH)
Any Quarter
Undertaken with the approval of the candidate's advisor and the Department Graduate Committee.

IIS 3873 Industrial Engineer Degree Project (4QH)
Any Quarter
Same as IIS 3870.

IIS 3874 Industrial Engineer Degree Project (2QH)
Any Quarter
Same as IIS 3870.

IIS 3885 Doctoral Thesis (0QH)
Doctoral Thesis research conducted under the advisorship of the student's dissertation committee. Prep. Admission to doctoral candidacy.

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers the degrees of Master of Science in Mechanical Engineering, Mechanical Engineer, and Doctor of Philosophy. The Master of Science degree may be pursued on either a full-time or a part-time basis. A full-time student may apply for participation in the Cooperative Plan. The Mechanical Engineer and Doctor of Philosophy degrees are pursued on a basis consistent with the residence requirements for the degree. The curriculum offers areas of concentration in Materials Science and Engineering, Mechanics and Design, and Thermofluids Engineering. In addition, the department administers the CAD/CAM option of the Computer Systems Engineering program, through which students may pursue a program in Design and Manufacturing.

Master of Science Degree Requirements

Students who have been accepted into the program and have received the degree of Bachelor of Science in Mechanical Engineering, or a closely-allied engineering field from a recognized college or university, will qualify for the Master of Science in Mechanical Engineering degree upon successful completion of program requirements. Students with a Bachelor of Science degree in other engineering or related science fields will qualify for the degree of Master of Science without specification.

A minimum of forty-four quarter hours of graduate study is required for the Master of Science degree. Full-time students, both continuous and cooperative, are required to complete a seminar program and a thesis for twelve quarter hours of credit. The thesis and seminar program are not required of part-time students. All students must consult with their advisor or the Department's assigned Graduate Officer for course sequencing and the selection of elective courses in each area of concentration.

Mechanics and Design

Course Requirements

	Full-time Study	Part-time Study
Required Core Courses	16 QH	16 QH
Required Electives	10 QH	18 QH
Thesis	12 QH	0 QH
Other Courses	6 QH	10 QH
Minimum Quarter Hours Required *	44 QH	44 QH

*exclusive of any preparatory courses

Required Core Courses

	Credits
ME 3100 Math. Methods for Mechanical Engineers	4
ME 3120 Theory of Elasticity	4
ME 3140 Advanced Dynamics	4
ME xxxx Required Core Course from Thermofluids Engineering or Materials Science and Engineering	4

Required Electives

ME 3400 - ME 3539 Adv. Electives in Mechanics or Design.....10 or 14
Thesis - ME 3860, ME 3861, ME 3862.....0 or 12

Other Courses

Advanced Courses in Engineering or Science
no more than six (6) quarter hours outside the department..... 6 or 10
*prepatory courses (e.g. IIS 3100-3199) may not be used unless approved by the graduate advisor

Thermofluids Engineering

Course Requirements

	Full-time Study	Part-time Study
Required Core Courses	16 QH	16 QH
Required Electives	8 QH	8 QH
Thesis	12 QH	0 QH
Advanced ME Electives	0 QH	12 QH
Other Courses	8 QH	8 QH
Minimum Quarter Hours Required*..	44 QH	44 QH

*exclusive of any preparatory courses

Required Core Courses

	Credits
ME 3100 Math. Methods for Mechanical Engineers	4
ME 3200 General Thermodynamics	4
ME 3210 Essentials of Fluid Dynamics	4
ME xxxx Required Core Course from Mechanics or Materials Science and Engineering	4

Required Electives Selection

ME 3540 Heat Conduction and Thermal Radiation..... 4
ME 3544 Convective Heat Transfer.....4
ME 3560 Viscous Flow.....4
ME 3564 Gas Dynamics.....4
ME 3580 Statistical Thermodynamics.....4
ME 3584 Fundamentals of Combustion..... 4
Thesis - ME 3860, ME 3861, ME 3862.....0 or 12
Advanced ME Electives (ME 3400 - ME 3699).....0 or 12

Other Courses

Advanced Courses in Engineering or Science with no more than six (6) quarter hours outside the department *.....8
*prepatory courses (e.g. IIS 3100-3199) may not be used unless approved by the graduate advisor

Materials Science and Engineering

Course Requirements

	Full-time Study	Part-time Study
Required Core Courses	20 QH	20 QH
Math Elective	4 QH	4 QH
Advanced Material Elective	0 QH	12 QH
Advanced Courses in Eng'g, Math and Science	8 QH	8 QH
Thesis	12 QH	0 QH
Minimum Quarter Hour	44 QH	44 QH

Required Core Courses

	Credits
ME 3252, ME 3600 Advanced Physical Metallurgy	6
ME 3264 Thermodynamics of Materials	4
ME 3272, ME 3602 Material Science & Engineering	6
ME xxxx Required Core Course from Mechanics or Thermofluids Engineering*	4

*ME 3100 and ME 3200not eligible

Thesis

Thesis - ME 3860, ME 3861, ME 3862 12

Math Electives

ME 3100 Math Methods for Mechanical Engineers 4
MTH 3222 Applied Statistics 4
IIS 3113 Basic Probability and Statistics 4

Advanced Materials Electives

ME 3431 Engineering Fracture Mechanics 4
ME 3434 Advanced Engineering Fracture Mechanics 2
ME 3521 Introduction to Plasticity 2
ME 3601 - ME 3659 26
CHE 3600 Polymer Science 4
ECE 3384, 3388 Charac. and Models of Solid St. Dev. I, II ..... 4 each
ECE 3583, 3584, 3585 Optical Properties of Matter ..... 2 each
ECE 3600 Microwave Properties of Materials 4
ECE 3626, 3629 Integrated Circuit Fabrication Processes ..... 4 each

Advanced Courses in Engineering, Math and Science

These courses include those listed under Advanced Materials Electives as well as those in other departments in the university.

The Mechanical Engineer Degree

The Mechanical Engineer degree program is offered for those who wish to undertake graduate study beyond the Master of Science degree without committing themselves to a program as extensive or specialized as that required for the Doctor of Philosophy degree. The program permits a candidate to pursue a course of study at the upper graduate level in more than one area of Mechanical Engineering as distinguished from the specialization usually associated with the doctoral program.

Qualification, Degree Candidacy and Examinations

A student admitted to the Mechanical Engineer degree program will be designated a Candidate for this degree. The Candidate's advisor normally will be the faculty member who will supervise the thesis. A student must maintain a 3.00 grade point average to qualify for the degree. Students admitted on a conditional basis may be required to pass special examinations. The Graduate Committee will determine the need for and will administer any such special examinations. A final oral examination consisting of a defense of the thesis may be required if the Candidate's advisor so decides.

Program Requirements

A minimum of 40 quarter hours of credit beyond the Master of Science degree is required. Up to 10 quarter hours of credit will be permitted for work on a thesis. A student would have chosen two areas of concentration prior to acceptance to furnish the broad background which characterizes the degree of Mechanical Engineer.

Any transfer of credits must be approved by the Mechanical Engineering Graduate Committee. After admission to the program, a maximum of five years will be permitted for completion of the degree. Following approval of the Candidate's program, registration must be continuous. Withdrawal or changes in the program must be approved by the Graduate Committee.

Language Requirement

There is no language requirement for the Mechanical Engineer degree.

Residence Requirement

The residence requirement is satisfied by two academic quarters of full-time graduate work during the academic year or by four academic quarters of half-time graduate work during two consecutive academic years. Plans for satisfying the residence requirement on a half-time basis must be approved by the Graduate Committee.

Thesis

To be awarded the Mechanical Engineer degree, each candidate must complete a thesis demonstrating a high level of competence in research, development, or design in the field of Mechanical Engineering. The effort normally expected will be the equivalent of ten quarter hours of graduate course work.

The Doctor of Philosophy Degree

The degree of Doctor of Philosophy (Ph.D.) is awarded to those candidates who demonstrate high attainment and research competence in the field of Mechanical Engineering. Upon acceptance into the program, a student is designated a *Doctoral Student.* A doctoral student who has completed the equivalent of an MS program in Mechanical Engineering or 40 quarter hours of graduate work with satisfactory grades becomes a *Doctoral Candidate* upon successful completion of the doctoral *Qualifying Examination.* After candidacy has been established, a candidate must complete a dissertation under the direction of a *Dissertation Advisor* and a program of course work. To receive the *Ph.D.* degree a candidate must pass a *Final Oral Examination.*

Qualifying Examination

The *Qualifying Examination* is offered yearly, normally in the Winter Quarter, and comprises both written and oral parts. The objective of the written part is to test the student's knowledge and comprehension of the basic concepts and fundamentals in mechanical engineering. Upon successful completion of the written part, the student is allowed to take the oral part, which is administered to test general comprehension and capability for successful completion of the program. All Doctoral Students must take and pass the qualifying examination within 18 months of acceptance into the program. Because degree candidacy must be established before the Graduate Committee will act to approve the course program and dissertation proposal, the qualifying examination should be taken at the earliest opportunity.

The written part is six hours in length and covers, with equal emphasis, four different areas. The student must choose two areas, each from one of the following four groups A, B, C, and D, plus two more either listed below or unlisted, but considered equivalent and approved by the Graduate Committee.

A. Thermodynamics, Fluid Mechanics, Heat Transfer

B. Dynamics, Mechanics of Deformable Bodies

C. Materials Science, Mechanical Behavior of Materials, Physical Metallurgy

D. Engineering Mathematics

At least two of the four areas should be those closest to the specialty area in which the student plans to do his or her doctoral thesis work, and at least one area must be another specialty area of Mechanical Engineering (excluding Engineering Mathematics).

A student who is classified as interdisciplinary may request modifications in testing areas. Requests must be approved by the Graduate Committee.

The oral part is conducted by a committee consisting of at least four members appointed by the Graduate Committee. A typical committee is composed of at least one member from each of the four specialty areas in which the student has chosen to be examined in the written part.

Dissertation and Course Requirements

Soon after degree candidacy has been established, the doctoral candidate has to petition the graduate committee to appoint a *Dissertation Committee*. The Dissertation Committee will be chaired by the student's dissertation advisor and includes at least two other members, with one member from outside the student's major area. The doctoral candidate will propose a *Dissertation Topic* and *Program of Study* to the Dissertation Committee. The topic and program will be formally presented to the Dissertation Committee for approval at a session with the doctoral candidate. A typical program includes at least 36 quarter hours of course work beyond the M.S. degree with at least 12 quarter hours of the course work in an area other than that in which the candidate is concentrating (which may also be taken outside the department). Attainment of a minimum 3.00 grade point average for the courses in the "minor" portion of the program will signify satisfactory completion of that portion of the course work. Upon successful completion of the PhD qualifying examination and the majority of required coursework, the student is required to register in three consecutive quarters for ME 3880 (Dissertation). Upon completion of this sequence, the student is required to register for ME 3799 (PhD Continuation) in every quarter until the dissertation has been completed. Students may not register for continuation until the three-quarter thesis sequence has been fulfilled.

Final Oral Examination

The candidate presents his/her dissertation to the Dissertation Committee for review. A *Final Oral Examination* is scheduled after the Dissertation Committee agrees that the dissertation is in an appropriate form for a formal presentation and after completion of all other requirements for the Ph.D. degree. Upon successful completion of the examination, the doctoral candidate is recommended to receive the Ph.D. degree.

Language Requirement

A reading knowledge of one foreign language of technological and scientific importance is normally required. Proficiency in a language shall be determined in a manner prescribed by the departmental Graduate Committee. The doctoral candidate may, with the approval of his/her dissertation advisor, petition the graduate committee to waive the requirement for proficiency in a foreign language.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work or by two years of half-time graduate work beyond the Master of Science degree. However, a student should expect to spend at least three years, or the equivalent, in full-time graduate study beyond the requirements of the Master of Science degree.

Faculty

John W. Cipolla Jr., Chairman
Mohamad Metghalchi, Associate Chairman

Professors

Adams, George G., PhD, University of California at Berkeley; response of elastic structures to moving loads, tribology, stress distributions at material interfaces, elasticity, stability

Berg, Charles A., ScD, Massachusetts Institute of Technology; mechanical properties of materials, fracture, fatigue and wear, engineering properties of materials, energy conservation and advanced technology, history of technology, engineering aspects of economics

Cipolla, John W., Jr., PhD, Brown University; laser-aerosol interactions including thermophoresis, heat and mass transfer, radiative transfer, kinetic theory

Gorlov, Alexander M., PhD, Moscow Institute of Transport Engineers; mechanical design of complex systems, mechanical apparatus for harnessing tidal and low head hydro power, transporting of ships by land, general applied mechanics problems

Murphy, Richard J., PhD, Massachusetts Institute of Technology; metal matrix composites

Nowak, Welville B., *Donald W. Smith Professor of Mechnical Engineering*, PhD, Massachusetts Institute of Technology; materials science and engineering, thin films for resistance to corrosion, diffusion and wear, photovoltaic solar cells, electronic materials

Rossettos, John N., PhD, Harvard University; buckling and vibration of stiffened plates, mechanics of damage in composite materials, applied mechanics

Yener, Yaman, PhD, North Carolina State University; thermal radiation, heat and mass transfer, radiative transfer, aerosol thermophoresis with radiation

Zeid, Ibrahim, PhD, University of Akron; CAD/CAM, finite-element method, applied mechanics, design, manufacturing, geometrical modeling, concurrent design methodologies

Associate Professors

Blucher, Joseph T., PhD, Massachusetts Institute of Technology; surface treating processes CVD, PVD, ion nitriding, and laser processing; metal matrix composites, powder metallurgy, welding, cutting tools, manufacturing processes, failure analysis, fracture, fatigue, wear

Finn, Charles W., PhD, Massachusetts Institute of Technology; materials processing, fine powder sintering, pyrometallurgy, high temperature chemical thermodynamics and kinetics.

Hashemi, Hamid N., PhD, Massachusetts Institute of Technology; materials, composite materials, nondestructive evaluation, mechanics, finite-elements, fatigue, wear, reliability-centered maintenance

Ilegbusi, Olusegun J., PhD, Imperial College of Science and Technology, University of London; turbulence modelling with emphasis on transition, instability and mixing. Mathematical and physical modelling of multi-phase phenomena and materials processing operations. Processing and applications of metal-matrix composites.

Kowalski, Gregory J., PhD, University of Wisconsin-Madison; combined modes of heat transfer in participating media, solar energy, thermal electronic packaging, combined heat and mass transfer

Metghalchi, Mohamad, ScD, Massachusetts Institute of Technology; laminar and turbulent flame propagation, stability in internal combustion engines, energy conversion, air pollution, chemical kinetics, advanced thermodynamics

Narusawa, Uichiro, PhD, University of Michigan; natural and double-diffusive convection in enclosures and saturated porous media, two-phase flows, thermocapillary flow

Taslim, Mohammad E., PhD, University of Arizona; computational and experimental fluid mechanics and heat transfer, double-diffusive convection

Assistant Professors

Levendis, Yiannis A., PhD, California Institute of Technology; combustion, incineration, air pollution, chemical kinetics, aerosol physics, internal combustion engines

Tangborn, Andrew V., PhD, Massachusetts Institute of Technology; computational fluid dynamics, spectral methods, chaos and the origins of turbulence

Williams, Mary G., PhD, University of Illinois; theoretical and applied mechanics, fluid mechanics, peturbation methods, applications to MHD flows in materials processing

Wilson, Bruce H., PhD, University of Michigan; mechanical computer-aided engineering, automated modelling, dynamic systems and control, computer-aided design and control of drive train systems

Program Advisors

Materials Science & Engineering	Prof. W. Nowak
Mechanics and Design	Prof. H.N. Hashemi
Thermofluids Engineering	Prof. U. Narusawa
CAD/CAM	Prof. I. Zeid

MECHANICAL ENGINEERING

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time. "Odd" and "Even" years refer to the fall quarter of the academic year, i.e., Spring 94 which is in the 93-94 academic year, would be an "odd" year.

ME 3100 Mathematical Methods for Mechanical Engineers (4QH)
Fall Quarter
A comprehensive course designed to integrate undergraduate mathematics into a solid foundation of graduate mathematics. Topics will likely include infinite series, generalized functions and the Laplace transform, special functions, vector field theory, linear space theory, and eigenvalue and eigenfunction theory. These techniques and other methods will be used to solve both ordinary and partial differential equations. Prep. Admission to the Graduate School of Engineering.

ME 3120 Theory of Elasticity (4QH)
Winter Quarter
Analysis of Cartesian tensors using indicial notation. Stress and strain concepts; point stress and strain; relation to tensor concepts. Governing equations for the determination of stress and displacement distributions in a solid body. Exact solutions of the governing equations for elastic solids. Plane stress and strain problems in rectangular and polar coordinates including thermal stress. Relation of elasticity theory to strength of materials. Torsion of prismatic and axially symmetric bars. Bending of thin flat rectangular and circular plates. Prep. Admission to the Graduate School of Engineering.

ME 3140 Advanced Dynamics (4QH)
Spring Quarter
Kinematics of particles and rigid bodies including moving reference frames. Modeling and application of fundamental laws of motion. Dynamic response of lumped parameter systems. Lagrange's equations. Applications in two and three dimensions. Prep. Admission to the Graduate School of Engineering.

ME 3200 General Thermodynamics (4QH)
Winter Quarter
Fundamentals of equilibrium thermodynamics will be examined. Topics may include: work, energy, heat, temperature, available energy, entropy, first and second law of thermodynamics, simple systems, closed and open systems, availability loss and irreversibility, heat engines, multicomponent systems, mixtures of gases, chemical reactions and chemical equilibrium. Prep. Admission to the Graduate School of Engineering.

ME 3210 Essentials of Fluid Dynamics (4QH)
Fall Quarter
A fundamental course in fluid dynamics designed to prepare the student for more advanced courses in the thermofluids curriculum while providing a strong background in fluid mechanics. Topics to be covered may include: Cartesian tensors; differential and integral formulation of the equations of conservation of mass, momentum and energy; molecular and continuum transport phenomena; the Navier-Stokes equations; vorticity; inviscid, incompressible flow, the velocity potential and Bernoulli's equation; viscous incompressible flow; the stream function; some exact solutions; energy equation including heat conduction and viscous dissipation. Prep. Admission to the Graduate School of Engineering.

ME 3252 Advanced Physical Metallurgy I (4QH)
Fall Quarter
Dislocation theory; including such topics as dislocation stress fields, self-energy, velocity, interactions mechanisms, image forces, and theories of yielding, Mechanical behavior of metals. Application of dislocation theory to micro-plasticity, strain hardening, strengthening mechanisms and creep. Prep. A recent introduction to material science course.

ME 3264 Thermodynamics of Materials (4QH)
Winter Quarter
Basic materials thermodynamics encompassing first, second, and third laws, entropy, enthalpy, and free energy. Emphasis on solutions, activity, activity coefficients, the phase rule and applications to some materials problems. Prep. Undergraduate Thermodynamics.

ME 3272 Materials Science and Engineering I (4QH)
Fall Quarter
Principles underlying the structure and properties of solid materials. The relationships of these principles to the properties and to applications in structures and devices. Both macroscopic-phenomenological and electronic-molecular approaches will be used. Materials will include metals and alloys, semiconductors, and dielectrics. Typical subjects are atomic and electronic structures, ordering, crystal growth, and thermal properties. Prep. A recent introductory material science course.

ME 3341 Power Generating Systems I (2QH)
As Announced
Power generating systems that employ fossil, nuclear, and heat recovery boilers operating in conjunction with steam and organic Rankine cycles are examined. The steady-state and transient operation of each power generating system is studied from both an analytical and conceptual point of view. The effect that site conditions, fuel quality, plant loading schedule and environmental regulations have on system design, performance and operation is presented. Prep. ME 3200 or equivalent, ME 3200 may be taken concurrently with permission of instructor.

ME 3342 Power Generating Systems II (2QH)
As Announced
An extension of ME 3341. The same type of examination is conducted of systems incorporating gas, hydraulic, and wind turbines, solar and fuel cells, energy storage, combined cycles, and cogenerating systems. The objective of Power Generating Systems I and II is to develop the skills needed to conduct sound technical evaluations of the power generating systems being built today. Prep. ME 3341.

ME 3343 Power Generation Economics and Planning (2QH)
As Announced
Current and constant-dollar power generation costs are examined. Life cycle economic analysis, such as revenue requirements, discounted cash flow, internal rate of return, and payback analyses, are presented. The planning methodologies used by electric utilities and private industry to evaluate and select power generating systems are presented. Prep. ME 3342.

ME 3351 Solar Thermal Engineering I (2QH)
As Announced
A model is developed for the hourly direct and diffuse radiation under a cover of scattered clouds and the transmission and absorption of this radiation by passive and active systems. The design of air heating systems and the storage of the collected energy by a pebble-bed are considered, as well as elements of heat exchanger design. A study of the economics of a domestic water and/or space heating system is made using f-chart analysis. Prep. CHE 3660, Solar Energy Thermal Processes or equivalent background.

ME 3352 Solar Thermal Engineering II (2QH)
As Announced
The design and analysis of several solar thermal systems are considered, such as: LiBr-H20 absorption cooling units, heat pumps, compound parabolic collectors, and the heat pipe type of solar collector. Prep. ME 3351.

ME 3360 Turbomachinery Design (4QH)
As Announced
Preliminary design methods and analytical tools applicable to turbomachinery are presented. Design criteria and performance characteristics at design and off-design operating conditions are discussed for several important types of turbomachinery. Axial flow compressors and turbines (gas and steam) are studied in some depth, including topics such as compressor surge, turbine blade cooling, and steam wetness effects. Centrifugal compressors, radial inflow turbine, pumps, fans, and water turbines are also studied. Turbomachinery mechanical design limitations are discussed. The use of empirical data on blade cascade performance in blade selection is examined. Numerical methods of analyzing two- and

three-dimensional flows in turbomachinery (e.g., conformal transformation and streamline curvature) are presented. Two in-depth design projects are assigned. Prep. Admission to the Graduate School of Engineering, including undergraduate preparation in fluid mechanics and thermodynamics.

ME 3370 Fundamentals of Maintenance in Design (4QH)
Spring Quarter, Odd Years
Basic tools of probability analysis will be covered. Failure modes and actual functional behavior of designed components will be presented in the probability forms. Age reliability will be discussed. Nondestructive evaluation techniques will be presented and demonstration tests will be performed. Fault tree analysis and decision logic will be covered. Prep: Admission to the Graduate School of Engineering.

ME 3380 Fundamentals of Instrumentation (2QH)
Fall Quarter, Even Years
Theoretical principles underlying the design and operation of instruments for measurement and/or control. Analysis of stimulus-response relations. Industrial instruments for measurement and control, including those based on pneumatic and electrical systems. Prep. Bachelor of Science degree.

ME 3381 Industrial Process Control (2QH)
Winter Quarter, Even Years
Fundamental principles involved in automatic control of industrial processes. Economic considerations. Application of control instruments to obtain automatic control of temperature, pressure, fluid flow, liquid level, humidity, PH. Prep. ME 3380.

ME 3386 Nuclear Engineering I (2QH)
As Announced
Topics include: growth of nuclear power industry; study of nuclear physics emphasizing atomic and nuclear structure, radioactive decay, and nuclear reactions with particular attention to fission and fusion; radiation health physics; principles of shielding; nuclear instrumentation; production and application of radioisotopes; neutron interactions and slowing down theory; neutron activation analysis. (Not open to students who have completed ME 1541 and ME 1542). Prep. Admission to the Graduate School of Engineering.

ME 3387 Nuclear Engineering II (2QH)
As Announced
Comparison of thermal, fast, and breeder reactors; four factor formula and the neutron diffusion equation; one-group, modified one-group, two-group and multi-group theory; bare and reflected thermal reactors; energy production and distribution within core; flux shaping; transient reactor behavior and control; factors affecting reactivity including temperature, pressure, void formation, fission product accumulation, fuel depletion and fuel breeding; Xenon buildup after shutdown. (Not open to students who have completed ME 1541 and ME 1542). Prep. ME 3386.

ME 3388 Nuclear Engineering III (2QH)
As Announced
Reactor design considerations; interrelationship of reactor physics, control, engineering, materials, safety, and fuel cycle management; reactor types; radiation damage and reactor materials; nuclear fuels; reactor heat transfer; economics of nuclear power; environmental effects. (Not open to students who have completed ME 1541 and ME 1542). Prep. ME 3387.

ME 3400 Advanced Math Methods for Mechanical Engineers (4QH)
Fall Quarter, Odd Years
Variational calculus and applications. Complex variables. Approximate methods of engineering analysis. Integral transforms; asymptotic expansion; regular and singular perturbation methods. Examples drawn from solid mechanics, vibration, and fluid mechanics. Prep. ME 3100.

ME 3410 Numerical Methods in Mechanical Engineering (4QH)
Winter Quarter
Numerical methods applied to problems in mechanical engineering. Solution of linear and non-linear systems of equations, interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations: explicit and implicit methods, multi-step

methods, predictor-corrector methods. Numerical solution of partial differential equations with emphasis on parabolic and elliptic problems occurring in mechanical engineering. Prep. ME 3100 and knowledge of a programming language.

ME 3420 Mechanics of Inelastic Solids (4QH)
As Announced
Constitutive relations governing inelastic solids. Yield surface; plastic stress-strain relations; Prandtl-Reuss equations. Viscoelastic stress-strain relations including the Maxwell and Voigt models. Viscoplasticity. Prep. ME 3120. Not available to students who have taken ME 3421.

ME 3421 Introduction to Plasticity (2QH)
Winter Quarter, Even Years
Basic experimental information. Review of stress and strain tensors. Elastic stress-strain relations. Yield surface. Plastic stress-strain relations. Prandtl-Reuss equations. Simple applications. Prep. ME 3120.

ME 3423 Advanced Theory of Elasticity (2QH)
Spring Quarter, Even Years
Approximate solutions for stress and displacement distributions in elastic solids; discrete solutions using finite difference and finite element methods; energy principles and the calculus of variations; use of energy principles to obtain approximate continuous solutions. Prep. ME 3120.

ME 3431 Engineering Fracture Mechanics (4QH)
Fall Quarter, Odd Years
Fundamentals of brittle fracture; theoretical strength, micro/macro fracture characteristic, Inglis-Griffith theory, applicability of same. Linear elastic fracture mechanics; Orewan/Irwin extension to metals, effective surface tension and relation to fracture toughness, plastic zone size correction; geometry effects on fracture toughness; plane/strain stress fracture toughness, thickness effects. Experimental determination of fracture toughness; slow crack growth "pop in", arrest, R-G curves, compliance techniques for determining elastic energy release rate. Alternate fracture toughness concepts; resistance curve, crack opening displacement, the J integral. Application of fracture mechanics to fatigue. Design methods to minimize risks of catastrophic failure will be emphasized. Prep. ME 3120.

ME 3434 Advanced Engineering Fracture Mechanics (2QH)
As Announced
Application of fracture mechanics to fatigue, strain energy density criteria for fracture, arrest criteria. "Work of Fracture" specimen. Application of fracture mechanics to structural analysis. Effect of anisotropy in fracture mechanics. Fracture dynamics, dynamic fracture toughness, strain rate effects. Micro-second fracture phenomenon and criteria, spall, Butcher-Tuler criterion, NAG model. Residual strength, design approaches will be emphasized. Prep. ME 3431.

ME 3440 Advanced Mechanics of Materials (4QH)
Fall Quarter
Review of fundamental stress and deformation concepts; strain energy density; introduction to energy methods with application to beams, frames and rings; Ritz method. Beams on elastic foundations. Concept of stability as applied to one and two degree-of-freedom systems. Buckling of bars, frames and rings. Prep. Admission to the Graduate School of Engineering.

ME 3443 Advanced Topics in Mechanics of Materials (2QH)
As Announced
Selected topics in advanced mechanics; will vary with current interest. Prep. ME 3440, or consent of instructor.

ME 3446 Theory of Shells (2QH)
Spring Quarter, Odd Years
Membrane theory of shells. Analysis of cylindrical shells. General theory of thin elastic shells. Shells of revolution. Prep. ME 3120.

ME 3455 Mechanics of Composite Materials (2QH)
Winter Quarter, Odd Years
Constitutive equations for anisotropic laminated composite materials, and application to the structural response of beams and plates. Introduction to damage in fiber composites. Prep. ME 3120.

ME 3464 Automatic Control Engineering (4QH)
Fall Quarter, Even Years
Review of continuous-time system modeling and dynamic response, principles of feedback, classical control analysis and design techniques such as root-locus, and frequency-response. State-variable representation and optimal controller and estimator design introduced. Course project: modeling, analysis, and controller design of student-selected system. Prep. Undergraduate controls course or permission of instructor.

ME 3468 Robot Mechanics and Control (4QH)
Fall Quarter
Kinematics and dynamics of robot manipulators are the focus of the first part of the course. Kinematics cover the development of kinematic equations of manipulators, the inverse kinematic problems, and motion trajectories. Dynamics of manipulators for the purpose of control are covered employing Lagrangian mechanics. The second part of the course focuses on the control and programming of robot manipulators. Steady state errors and calculations of servo parameters are covered. High level programming languages are discussed. Prep. Admission to the Graduate School of Engineering.

ME 3470 Vibration Theory and Applications (4QH)
Spring Quarter
Laplace transformation techniques; phase-plane diagrams; multiple-degree-of-freedom systems; free and forced vibrations with and without damping. Systems with distributed mass and stiffness. Extensional, torsional and flexural vibrations of bars. Prep. ME 3140 or permission of instructor

ME 3474 Advanced Vibration Theory and Application (2QH)
As Announced
Selected topics of current interest in vibrations. Prep. ME 3470.

ME 3475 Random Vibration (2QH)
As Announced
Description of stochastic processes. Impulse response and frequency response of linear time-invariant dynamic systems. Correlations and spectra of stationary response. Crossing rates, peaks and envelopes. Failure under random loading. Poisson pulse processes. Measurement, identification, and response problems. Coherence. Space-time correlations and cross-spectra. Digital data processing. Application to vehicles and structures subjected to wide-band excitation. Prep. ME 3470.

ME 3480 The Finite Element Method (4QH)
Spring Quarter
Introduction to the finite element method. Variational formulations; simple interpolation functions and element stiffness matrices. Triangular and rectangular elements. Assembly technique and constraining of resulting equations. Elementary applications. Isoparametic element formulation of higher order and three dimensional elements. Rayleigh-Ritz and Galerkin formulations. Applications of finite element theory to mechanical engineering problems in the areas of solid mechanics, heat transfer, and fluid mechanics. The use of a finite element general purpose commercial package is included. Prep. ME 3100 or permission of instructor.

ME 3483 Advanced Finite Element Method (2QH)
Fall Quarter, Even Years
The dynamic finite element formulation with explicit and implicit time integration schemes for transient analysis. Solution methods for finite element equilibrium equations, including material and geometrical nonlinearities. General computer algorithms developed. Prep. ME 3480.

ME 3500 Computer Aided Graphics and Design (4QH)
Winter Quarter
Basic aspects of interactive computer graphics are covered. Topics include hardware and software concepts, design principles for the user-computer interface, geometrical transformation, display architecture, and data structures. Algorithms for removing hidden edges and surfaces, shading models, and intensity and colors are also covered. The second part of the course deals with the concepts of computational and numerical geometry and design of curves and surfaces. Solid modeling techniques are presented. Discussions of in-house computer aided graphics and Design packages are included. Prep. Admission to the Graduate School of Engineering and programming experience.

ME 3510 Manufacturing, Design and Computers (4QH)
Spring Quarter
Focuses on manufacturing and its relationship to design and computers. Covers fundamentals of manufacturing methods and systems. Examines relationship between design and various aspects of manufacturing. Computer modeling and related aids of various manufacturing activities are discussed. Topics include manufacturing systems, manufacturing processes, mechanical tolerancing, manufacturing features, process planning, principles of part programming (NC, CNC, DNC), and integration between CAD and CAM databases. Includes discussions of CAM packages. Students may gain hands-on experience by using in-house CAD and CAM facilities. Prep. ME 3500 or permission of instructor.

ME 3520 Experimental Techniques in Design (4QH)
Winter Quarter, Odd Years
In mechanical engineering, there is usually a need for verification of material properties, response simulation of the designed element, proof tests, and nondestructive testing of components. Design case histories will be utilized in defining appropriate experimentation needed for verification, simulation, proof tests, and inspection. These experiments may include, though they are limited to, tensile, fatigue, fracture toughness, vibration analysis, thermofluid analysis, and nondestructive testing. In this regard, the course will discuss the techniques associated with these experiments and methods of optimization of data and its acquisition. Prep. Admission to the Graduate School of Engineering.

ME 3525 Manufacturing Methods for Engineers (4QH)
Spring Quarter, Odd Years
This course focuses on manufacturing processes and their effects on the design and performance of engineering products. The first part of the course discusses the current processes and their applications. The second part discusses the design and manufacturing of products made of materials such as polymers and composites. Introduction to design and manufacturing of electronic components is included. Laboratory demonstrations are provided to illustrate various manufacturing processes. Prep. Admission to Graduate School of Engineering.

ME 3540 Heat Conduction and Thermal Radiation (4QH)
Winter Quarter
Formulation of steady and unsteady state one - and multi-dimensional heat conduction problems. Solution techniques for linear problems including the method of separation of variables, Laplace transforms and integral transforms. Approximate analytical methods. Phase change problems. Non-linear problems. Nature of thermal radiation. Blackbody and radiation from a blackbody. Radiation from a non-black surface element. Radiative exchange among surfaces separated by a non-participating medium. Interaction of radiation with other modes of heat transfer in non-participating media. Prep. ME 3100 and undergraduate heat transfer.

ME 3544 Convective Heat Transfer (4QH)
Fall Quarter
Fundamental equations of convective heat transfer. Heat transfer in incompressible external laminar boundary layers. Integral boundary layer equations. Laminar forced convection in internal flows. Turbulent forced convection in internal and external flows. Analogies between heat and momentum transfer: the Reynolds, Taylor and Martinelli analogies. Natural convection. Heat transfer in high-speed flow. Transient forced convection. Prep. ME 3210 and ME 3540 or permission of instructor.

ME 3548 Radiative Transfer (4QH)
Spring Quarter, Even Years
Electromagnetic background. Fundamentals of radiation in absorbing, emitting and scattering media. Equation of radiative transfer. Methods of solution of the equation of radiative transfer. Pure radiative transfer in participating media. Interaction of radiation with conduction and/or convection. Prep. ME 3540.

ME 3552 Two Phase Flow (4QH)
As Announced
The basic concepts of heat and mass transfer associated with phase change and multi-phase flows. Some of the specific subjects to be discussed are: boiling heat transfer (nucleate boil-

ing, film boiling and bubble dynamics); evaporation and condensation; liquid-gas two phase flow and gas-solid and liquid-solid two phase flows. Prep. ME 3100 (or equivalent) and undergraduate heat transfer.

ME 3556 Heat Transfer Processes in Microelectronic Devices (4QH)
Spring Quarter
Discussion and development of state-of-the art methods used to predict the heat transfer rates from microelectronic devices and packages and to simulate transport phenomena in manufacturing processes associated with microelectronic devices. Topics will be selected from the current literature and may include use of latent heat reservoirs, boiling jet impingement cooling, control volume approaches to extended surfaces, calculation of thermal contact conductances and natural convection in enclosures. Simulation of laser assisted thermophoretic deposition and laser cladding processes will also be developed. Prep. ME 3100 (or equivalent) and undergraduate heat transfer or consent of instructor.

ME 3560 Viscous Flow (4QH)
Winter Quarter, Odd Years
Review of conservation of mass, momentum, and energy for compressible viscous flow. Discussion of the mathematical character of the basic equations and analysis of some exact solutions. Investigation of low Reynolds number flow. Exact and approximate approaches to laminar boundary layers in high reynolds number flows. Stability of laminar flows and the transition to turbulence. Treatment of incompressible turbulent mean flow; internal and external flows. Extensions to compressible boundary layers. Prep. ME 3100 and ME 3210.

ME 3564 Gas Dynamics (4QH)
Spring Quarter, Odd Years
The consequences of fluid compressibility are studied. Shock waves and the theory of characteristics are discussed with specific consideration given to two-dimensional steady flows and one-dimensional unsteady flows. Additional topics may include axially symmetric steady flow, small perturbation theory, similarity rules, the hodograph method, or some aspects of physical acoustics. Prep. ME 3210.

ME 3568 Computational Fluid Dynamics With Heat Transfer (4QH)
Spring Quarter
Finite difference methods for solving partial differential equations with particular emphasis on the equations of fluid dynamics and convective heat transfer. Integral methods for boundary layers and their coupling to potential flow solutions. Use of coordinate transformations and body-oriented coordinate systems. Application of superposition techniques in convective heat transfer problems. Prep. ME 3210 and ME 3410.

ME 3572 Aerosol Mechanics (4QH)
As Announced
This course studies the behavior of ultrafine particles from both microscopic and macroscopic viewpoints. First the microscopic origins of aerosol transport phenomena are discussed including Bownian diffusion, drag, thermophoresis, condensation and evaporation. This is followed by a discussion of deposition processes for monodisperse aerosols including distribution function for polydisperse aerosols, the general dynamic equation and methods of solution, homogeneous nucleation, and coagulation. Industrial applications will be introduced where appropriate. Prep. ME 3100, 3200, 3210 or permission of instructor.

ME 3580 Statistical Thermodynamics (4QH)
Spring Quarter, Even Years
An introductory course in statistical thermodynamics for Mechanical Engineers designed to provide insight into the laws of classical thermodynamics and the behavior of substances. Topics to be covered include: Introduction to probability; elementary kinetic theory of an ideal gas including the distribution of molecular velocities and the mean free path treatment of transport properties; classical statistics of independent particles, equipartition of energy, the partition function and laws of thermodynamics; some results from quantum mechanics, quantum statistics of independent particles; applications to gases; introduction to ensembles and systems of interacting particles. Prep. ME 3100 and ME 3200 or equivalent.

ME 3584 Fundamentals of Combustion (4QH)
Fall Quarter, Even Years
Comprehensive treatment of the problems involved in the combustion of liquid, gaseous, and solid fuels in both laminar and turbulent flow. The fundamentals of chemical kinetics will be discussed. The equations for the transport of mass, momentum, and energy with chemically reacting gases will be examined. Topics will include diffusion and premixed flames, combustion of droplets and sprays, and gasification and combustion of coal. Prep. ME 3200.

ME 3588 Combustion and Air Pollution (4QH)
Fall Quarter, Odd Years
This course deals with the formation of pollutants during combustion processes and their subsequent transformations in the atmosphere. Emphasis will be placed on the effects of design and operating parameters of combustion devices on the nature and composition of exhaust gases, improvements, post-combustion treatment of effluent gases, atmospheric chemistry, and atmospheric transport of pollutants, smog formation, acid rain, ozone formation and destruction. Prep. Undergraduate course in thermodynamics, heat transfer and fluid mechanics, or permission of instructor.

ME 3600 Advanced Physical Metallurgy II (2QH)
Winter Quarter
The kinetics of phase transformations in metals. Topics include kinetic theory, empirical kinetics, diffusion in metals, nucleation, diffusional growth, martensitic transformations. Prep. ME 3252.

ME3601 Thermodynamics of Alloy Systems(2QH)
Spring Quarter
The application of materials thermodynamics to various process problems, solution modelling, and thermodynamic systems analysis. Prep. ME 3264 or ME 3200.

ME 3602 Materials Science and Engineering II (2QH)
Winter Quarter
Continuation of ME 3272 into electric, magnetic and dielectric properties Prep. ME 3272.

ME 3603 Corrosion I (2QH)
As Announced
The study of the thermodynamics of corrosion and corrosion reactions both in aqueous and non-aqueous environments. Topics will include thermodynamics, kinetics, and the effects of environment and physical metallurgy. Prep. Admission to the Graduate School of Engineering.

ME 3604 Corrosion II (2QH)
As Announced
Continuation of ME 3603. Prep. ME 3603.

ME 3607 Electronic Materials (4QH)
Spring Quarter
Generic techniques for fabrication and processing, and the resulting structure-property relationships, are presented for materials utilized in electronics. Typically included are: bulk single crystals, thin films, metals, semi-conductors, and insulators. Prep. ME 3272.

ME 3609 Diffraction Methods in Materials Science (4QH)
As Announced
Embodies the material in ME 3610 and ME 3611. Prep. A recent materials science course.

ME 3610 Introduction to Diffraction Methods in Material Science (2QH)
As Announced
General principles of the diffraction by materials of short wave length radiations; (such as x-ray, electrons, and thermal neutrons) are studied with emphasis on the understanding of the similarities and differences of the different radiations when applied to the study of the structures of crystalline and non-crystalline materials. Prep. A recent introductory material science course.

ME 3611 Diffraction Methods in Material Science (2QH)
As Announced
Continuation of ME 3610 with emphasis on the experimental methods and applications. This includes: choice of radiation, introduction to instrumentation, sample preparation, methods of detection and recording of the diffracted radiation, analysis, interpretation and use of the results. Prep. ME 3610.

ME 3612 Microstructure Analysis I (2QH)
As Announced
Discussion of the principles of scanning and transmission electron microscopy. Image interpretation in transmission electron microscopy with emphasis on the study of the relationships between microstructure and properties of materials. Application of kinematical and dynamical theories of electron diffraction to quantitative analysis of point defects, dislocations, precipitates and grain boundaries etc.. Laboratory demonstration of TEM and SEM operation. Prep. Admission to the Graduate School of Engineering.

ME 3613 Microstructure Analysis II (2QH)
As Announced
Continuation of ME 3612. Prep. ME 3612.

ME 3620 Powder Metallurgy (2QH)
Fall Quarter
Powder characteristics and methods of manufacture. Powder pressing: packing, interparticle bonding, effects of pressure. Principles of sintering. Characteristics and properties of products made from powdered materials. Prep. A recent introductory material science course.

ME 3625 Physical Ceramics I (2QH)
As Announced
Introduction to ceramic fabrication processes. Characteristics of vitreous and crystalline solids, structural imperfections, and atomic mobility. Phase equilibria, nucleation, crystal growth, solid-state reactions, non-equilibrium phases, and effects on the resulting micro-structure of ceramics. Prep. A recent introductory material science course, physical chemistry or solid state physics.

ME 3626 Physical Ceramics II (2QH)
As Announced
Discussion of effects of composition and microstructure on the thermal, mechanical, optical, electrical, and magnetic properties of ceramic materials. Prep. ME 3625.

ME 3627 Physical Ceramics (4QH)
As Announced
Embodies the material in ME 3625 and ME 3626.Prep. A recent introductory materials science course, physical chemistry, or solid state physics.

ME 3630 The Structure and Properties of Polymeric Materials I (2QH)
As Announced
Introduction to the organic chemistry of polymers, effect of chemical composition on structure, melting point and glass transition temperature, polymer characterization and degradation, thermodynamics of polymers. Prep. Undergraduate material science course.

ME 3631 The Structure and Properties of Polymeric Materials II (2QH)
As Announced
Rheology and mechanical behavior of polymers, analysis and testing, effects of processing on structure and physical properties, industrial polymers, resin base composites. Prep. ME 3630.

ME 3632 The Structure and Properties of Polymeric Materials (4QH)
As Announced
Embodies the material in ME 3630 and ME 3631. Prep. Undergraduate materials science course.

ME 3640 Computer Modeling of Materials Processing (2QH)
Fall Quarter, Even Years
Focus is on the use of numerical methods for modeling a variety of materials processing. Prep. Admission to the Graduate School of Engineering.

ME 3641 Computer Modeling of Materials Properties (2QH)
Fall Quarter, Odd Years
Various mathematical techniques and computer methods will be used to develop models that describe the changes in a material's chemical, mechanical, and physical properties as the chemical composition and metallurgical variables are changed. Prep. Admission to the Graduate School of Engineering.

ME 3797 Engineer Degree Continuation (0QH)
Any Quarter

ME 3798 Master's Degree Continuation (0QH)
Any Quarter

ME 3799 PhD Continuation (0QH)
Any Quarter

ME 3850 Special Problems in Mechanical Engineering (2QH)
Any Quarter
Theoretical or experimental work under individual faculty supervision. Prep. Consent of department faculty.

ME 3853 Special Topics in Mechanical Engineering (2QH)
Any Quarter
Topics of interest to the staff member conducting this class are presented for advanced study. Prep. Permission of department faculty.

ME 3854 Special Topics in Mechanical Engineering (4QH)
Any Quarter
Topics of interest to the staff member conducting this class are presented for advanced study. Prep. Permission of department faculty.

ME 3856 Doctoral Reading (2QH)
Any Quarter
Material approved by the candidate's advisor (only S or F grades will be assigned for this course). Prep. Passing of PhD Qualifying Exam.

ME 3860 Thesis (Master of Science Degree) (8QH)
Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3861 Thesis (Master of Science Degree) (4QH)
Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3862 Thesis (Master of Science Degree) (2QH)
Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3870 Thesis (Mechanical Engineer Degree) (10QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3871 Thesis (Mechanical Engineer Degree) (4QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3872 Thesis (Mechanical Engineer Degree) (2QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the department.. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3880 Dissertation (PhD Degree) (0QH)
Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Prep. Admission to the Doctoral Program in Mechanical Engineering.

ACADEMIC POLICIES AND PROCEDURES

A. Course Registration and Withdrawals

1. Program Approvals
2. Course Selections (Minimum Number of Courses; Choosing Courses
3. Thesis Continuation
4. Registration Procedures
5. Course Withdrawal Procedures
6. Common Registration Problems and Policies
7. Student ID Cards and Parking Stickers

B. Grading System

C. Academic Standards and Degree Requirements

1. Academic Classifications
2. Academic Requirements
3. Changes in Requirements
4. Class Hours and Credits
5. Code of Student Conduct
6. Continuity of Program
7. Filing for Degree
8. Incomplete Grades
9. Prerequisite/Advanced Undergraduate Courses
10. Time Limitations

D. Administrative Procedures

1. Change in Major
2. Change in Status (Classification)
3. Course Substitution
4. Course Waiver
5. Non-Graduate Engineering Courses
6. Thesis
7. Time Limit Extension
8. Transfer Credit

A - Course Registration & Withdrawals

A1 - Program Approvals

The curricula of the degree programs are given under each department heading. Descriptions of courses are given so that students may obtain a general view of the course coverage. Preparatory courses are indicated to students upon their acceptance. Not all courses are offered every year, but the courses are arranged in such a manner that students may make continuous progress toward their degrees. The Graduate School of Engineering issues a circular close to July lst which gives the expected course offerings for the following academic year and the times at which they will meet.

At the time of Fall Orientation, each full-time student must develop, with the assistance of his or her faculty advisor or the Department's assigned Graduate Officer, a complete program of study. Any subsequent changes must be approved by the advisor or the Department's assigned Graduate Officer. The Graduate School of Engineering makes available Advisor Sheets for program planning. These sheets are to be completed and a copy submitted to the Graduate School before a full-time student may proceed with his or her registration.

A2 - Course Selections

Minimum Number of Courses Required

Full-time students on Parallel Co-op should register for a minimum of eight (8) quarter hours per quarter in order to maintain full-time status. Continuous Full-time and Alternating Co-op Students must maintain twelve (12) to sixteen (16) quarter hours per quarter for continuous progress toward their degrees. Graduate Assistants should maintain at least eight (8) quarter hours per quarter for full-time status and the assistantship appointment. International Students on an F-1 or J-1 student visa must maintain full-time course loads as outlined above. The only exception to the minimum courseload for full-time status is if a student is in his or her last academic quarter or has completed all degree requirements and is registered in thesis continuation.

Part-time students may register for a maximum of six (6) quarter hours per quarter.

Choosing Courses

In selecting courses, full-time students should follow their advisor's or the Department's assigned Graduate Officer's approved schedule. Part-time students should follow the outlines presented in the department program section and confer with their advisor or the Department's assigned Graduate Officer for additional assistance as needed.

Courses, other than core courses, are offered according to the demand and the availability of faculty for specific areas. The student should preselect courses whenever possible and plan to take them when offered, maintaining flexibility with alternate courses in mind. There is no guarantee that any particular course will be offered, but the Graduate School of Engineering will do everything possible to assure continuity of programs.

To register for a course offered by a Graduate School at Northeastern other than Engineering, approval from the Graduate School of Engineering must be obtained before a student can petition the other graduate program. Refer to Administrative Procedures under the "Non-Graduate Engineering Courses" section.

Those students who need assistance in course selection, course sequencing, waivers and transfer credits should contact their advisor or the Department's assigned Graduate Officer or the Graduate School of Engineering. Additional information is provided under Administrative Procedures.

A3 - Thesis Continuation

Students who have not completed their thesis after having registered for the specified number of thesis credits must register for Thesis Continuation each subsequent quarter during the academic year until the thesis is completed. Thesis continuation carries no credit, but will appear on the student's transcript along with the appropriate grade for each quarter of registration. The continuation fee is one-half the tuition cost of one quarter hour for Master of Science and the cost of one quarter hour for Doctoral Degrees and Doctor of Engineering. Students who fail to register for Thesis Continuation will be charged retroactively at the time of degree conferral for any quarters in which they did not register and pay for their continuation fee.

A4 - Registration Procedures

Registration is mandatory. Any student who has failed to register properly before the end of the fifth week of classes will not receive a grade at the end of the quarter, even if the coursework was completed.

Engineer Degree and PhD students must register for course work or dissertation as approved by their advisors or the departmental registration officer. After the first registration for this work, registration must be continuous unless withdrawal is allowed by the committee in charge of the degree program. Doctoral students must be registered for dissertation during the quarter in which they take the final oral examination.

Mail registration is available for all regularly scheduled courses in all academic quarters. Materials are mailed at least four weeks prior to the quarter to all currently active students with the exception of Special Students. The forms should be completed and returned as soon as possible to the Registrar's Office. Course entrance is granted on a first-come, first-served basis, and past experience indicates that many courses close early in the registration process.

For adding or dropping courses following the mail registration period, students must go to the physical registration site to complete add/drop forms. In addition, there is a late registration period during the first week of classes at which further changes may be made.

Students planning to graduate within the calendar year are required to complete the pink Commencement Card available in the Registrar's Office and at all registration sites no later than the beginning of the quarter prior to graduation.

A5 - Course Withdrawal Procedures

In order to withdraw from a course, a student must fill out an official withdrawal form obtained at the Registrar's Office or at the Suburban Campus Office. In unusual circumstances, the Registrar's Office may be informed by letter. Withdrawals may be made through the ninth week of the quarter. However, withdrawals which are made after the fifth week of the quarter will be recorded with a "W" on the student's transcript.

Ceasing to attend a class, or simply notifying the instructor of intention to withdraw, does not constitute an official withdrawal. Students will be charged for the course tuition and will be subject to grades of "I" or "W" should they fail to officially withdraw.

Tuition refunds are granted only on the basis of the date on which the form is filed with the Registrar's Office. Students should keep their copy of the course withdrawal form to avoid any possibility of error. The Bursar's Office will credit a student's account or refund tuition in accordance with the following schedule:

Official Withdrawal Filed Within	%Tuition Refunded
First week of quarter	100%
Second week of quarter	75%
Third week of quarter	50%
Fourth week of quarter	25%

Requests for withdrawal from a course after the ninth week of the quarter may be submitted in writing to the Director of the Graduate School, and may be approved to avert unusual hardships on a student.

A6 - Common Registration Problems and Policies

Students who have pre-registered by mail will receive notification from the Registrar's Office in the event any selected course has been filled. The student must attend physical registration to register for an alternative course.

Class sizes are controlled by the Registrar and set by the Director of The Graduate School of Engineering in conjunction with the departments. The number of students enrolled in each class is limited to permit effective teaching at the graduate level. The University reserves the right to cancel, postpone, combine, or modify any course.

To register properly for any closed course, a student must obtain a *Closed Course Registration* form from the Graduate School of Engineering and submit the form at a scheduled registration. All appeals to enter a closed course must be submitted to the Director of the Graduate School for approval. Such permission is granted in cases where 1) the student has a prospective date of graduation the following June, the course is essential to his or her program, and the course cannot be taken in any of the following quarters, or 2) the student has successfully completed the first part of a sequential course. The addition of the student's name to the class list by the instructor does not constitute registration and will not entitle the student to a grade even if all the coursework is completed.

Due to last minute scheduling changes, the Graduate School will occasionally substitute faculty or change times for the class meetings after registration has begun. Any student who initially registered for the original course will automatically be registered for the new version should no major schedule conflicts be apparent. Otherwise, all registered students will be contacted for alternatives. Wherever possible, the Graduate School will attempt to satisfy these students' first options. Once the student has received notification of a time change and when the alternative results in a schedule conflict the student is responsible for making any registration changes.

Graduate Assistants must follow standard procedures for registering, dropping and adding courses. Registration conflicts with regard to work or teaching schedules must be resolved by the Graduate School and not the Registrar's Office.

Students are asked not to register for an excessive number of courses or double sections with the intention of dropping half or more of the courses during the first week of classes. "Double Section" requests will not be processed by the Registrar's Office. Over-registering complicates course and room scheduling, closes courses prematurely to genuinely interested students, and increases the number of changes and thus the chance of error. Students who abuse the registration process will jeopardize their program status.

Course credits earned in the Graduate School of Engineering are valid for a maximum of seven years in the Master of Science degree program, and up to five years in the Engineer Degree and PhD programs (once PhD degree candidacy has been established). (Refer to the ***Administrative Procedures*** section.)

All students who change their address, name or phone number during their enrollment in the Graduate School of Engineering should inform the Registrar and Graduate Engineering Office separately and in writing.

Any student who is financially withdrawn prior to the start of any given quarter must clear his or her financial obligation by the end of the fifth week of the quarter in order to receive academic credit. No grades will be processed for any student who remains financially withdrawn after the fifth week of any given quarter.

A7 - Student I.D. Cards and Parking Stickers

Part-time students will receive ID's in the mail approximately the second week of classes. If the ID card is lost, a replacement may be obtained through the Registrar's Office.

Full-time students receive photo ID cards during the Fall Orientation week; these are validated with the sticker the student may obtain from the Registrar's Office during the second week of each quarter that he or she is registered.

Parking stickers are obtained from the Traffic Office or the Suburban Campus Office by submitting a Cashier's payment card, car registration, driver's license and proof of registration (ID card or facsimile). Parking space is available on a first-come, first-served basis.

B - Grading System

The student's performance in graduate courses will be graded according to the following numerical equivalents.

A	(4.000)	This grade is given to those students whose performance in the course has been of very high graduate caliber.
A-	(3.667)	
B+	(3.333)	
B	(3.000)	This grade is given to those students whose performance has been at a satisfactory level.
B-	(2.667)	
C+	(2.333)	
C	(2.0)	This grade is given to those students whose performance in the course is not at the level expected in graduate work.
C-	(1.667)	
F	(0)	This grade is given to those students whose performance in the course is unsatisfactory.

In addition, the following letter designations are used:

I	Incomplete:	given to those students who fail to complete the work of the course; this work must be completed within one calendar year.
W	Withdrawal:	given to those students who were officially registered at the end of the fifth calendar week of a quarter and then officially withdrew from the class.
L	Audit:	given to those students who were officially registered to audit the class.
S	Satisfactory:	given to those students officially registered in Thesis courses or Thesis Continuation and making satisfactory progress. A grade is submitted when the thesis is submitted.
U	Unsatisfactory:	given to those students officially registered in Thesis courses or Thesis Continuation and making unsatisfactory progress. A grade is submitted when the thesis is submitted.

Individual faculty members may choose not to use the plus and minus designations. If they elect to use the whole letters only, they must announce this to the class at the beginning of the quarter.

C - Academic Standards and Degree Requirements

C1 - Academic Classifications

Students initially entering the Graduate School are classified into one of three groups according to their admission qualifications:

1. Regular students are those who meet in full all admittance criteria based on the standards established by the Committee on Graduate Study in Engineering.
2. Provisional students are those who do not qualify for regular admission based on the standards established. In order to continue in the Graduate School of Engineering and be reclassified as a regular student, a provisional student must obtain a 3.00 grade point average in their first twelve quarter hours of course work.
3. Special students are placed in a non-degree status and are limited to a maximum of twelve quarter hours of graduate credits.

C2 - Academic Requirements

All students must satisfactorily complete an approved program of correlated work of graduate caliber and such other study as may be required by the department in which he or she is registered. Regardless of classification, any student whose record is not satisfactory may be withdrawn from the Graduate School of Engineering.

To qualify for any degree from the Graduate School of Engineering a student must have a grade point average of not less than 3.00 with no more than 12 credits below a B- in all courses applied towards the degree, exclusive of prerequisite courses. The Committee on Graduate Study in Engineering allows eight quarter hours of credit to be taken beyond the stated degree requirements, to repeat failed required courses or substitute for elective courses to obtain the required 3.00 average for completion of degree requirements.

Within the above limitations for extra or repeated courses, a required course for which a grade of F is received must be repeated with a grade of C- or better.

Students who wish to audit a course must indicate this preference at registration. While no credit will be given for an audit, audits do appear on the student's transcript. Registration changes from an audit to a graded status in a course may not be made after the first day of classes.

C3 - Changes in Requirements

The continuing development of the Graduate School forces frequent revision of curricula and in every new bulletin some improvements are indicated. Students are held to the requirements in the bulletin of the year in which the student matriculated. However, they may elect to pursue the revised program requirements upon departmental approval.

C4 - Class Hours and Credits

All credits are entered as quarter hours. A quarter hour of credit is roughly equivalent to three fourths of a semester hour credit. All classes meet on a quarter basis. In the summer session,

some classes meet for two, six-week periods. The academic calendar in the Graduate Student Handbook should be consulted for the opening and closing dates of each academic quarter.

C5 - Code of Student Conduct

The Graduate School of Engineering will take immediate disciplinary action in all cases where a student has failed to adhere to the University rules and regulations for proper student conduct. Cheating, fabrication, facilitating academic dishonesty, and plagiarism are considered violations which may result in immediate dismissal from the Graduate Engineering program. Students should refer to the University's *Undergraduate and Graduate Student Handbook* for additional information.

C6 - Continuity of Program

Students are expected to maintain continuous progress toward their intended degree. A student who has attained 8 quarter hours of incomplete (I) grades and/or withdrawals may, at the discretion of the Committee on Graduate Study in Engineering, be withdrawn for failure to show continuous progress toward the degree.

C7 - Filing for the Degree

Each student who plans to graduate either in June or September must submit to the Graduate Registrar's Office a completed commencement data card prior to the deadline listed in the academic calendar for that commencement at which he or she expects to receive the degree. If the deadline for filing is not met, there is no assurance that the degree will be awarded that year. The commencement data card is supplied with the registration materials or is available in the Graduate Registrar's Office. It is the student's responsibility to make sure that degree requirements have been met, subject to confirmation by the Graduate School of Engineering.

C8 - Incomplete Grades

The I grade will be changed to a letter grade when the deficiency which led to the I is corrected to the satisfaction of and in the manner prescribed by the instructor in the course. The period for clearing such a grade will be restricted to one calendar year from the date of its first being recorded on the student's permanent record.

C9 - Prerequisite/Advanced Undergraduate Courses

Prerequisite courses will not be given credit towards degree requirements unless expressly stated by the individual departments. Advanced undergraduate courses are sometimes approved for degree credit. A request must be made on a graduate engineering petition form and submitted to the Graduate Engineering office for approval. (See the ***Administrative Procedures*** section.) The maximum number of credits allowed is determined by each academic department and are specified under the course descriptions for each department.

C10 - Time Limitations

Course credits earned in the program of graduate study, or accepted by transfer, are valid for a maximum of seven academic years in the Master of Science degree programs, up to five years in the Engineer Degree programs, and up to five years in the PhD and DEng programs once degree candidacy has been established. (Refer to ***Administrative Procedures*** section under *Time Limit Extension* petitions.)

D - Administrative Procedures

D1 - Change in Major*

A change of major area of concentration within the same department may be done on a petition form obtained from the Graduate Engineering office. The completed petition, along with an unofficial transcript of your graduate work, should be presented to your advisor or the Department's assigned Graduate Officer for his or her approval. All of these materials are then filed with the Graduate Engineering office for final approval and changing of your major code with the Registrar's Office.

D2 - Change in Status*

A change of status from full-time to part-time in the same program may be done by filing a completed petition with the Graduate Engineering office. No advisor's signature is needed. Due to immigration regulations, students on an F-1 or J-1 visa cannot request part-time status. If you are having academic difficulties, the Graduate Engineering School will recommend a remedial course of action for you.

To change status from part-time to full-time in the same program, you will need to have completed a minimum of 12 QH with at least a 3.0 grade point average. Present a completed petition and unofficial graduate engineering transcript to your advisor or the Department's assigned Graduate Officer for approval. All of these materials are then filed with the Graduate Engineering office for final approval and changing of your status code with the Registrar's Office.

**Please Note:* a change of major or status into a different department requires a re-application process. This can be done by requesting, preferably in writing, the Graduate Engineering office to bring your file before the new department's Admission Committee for review. An unofficial graduate engineering transcript, and any other materials needed, should be provided by you to the Graduate Engineering office.

D3 - Course Substitution**

A course substitution is the replacement of a graduate level course already taken with an equivalent graduate level course. The Registrar's Office will automatically designate

"Repeat" by a course when you retake the same course. However, when a two-part sequence (as offered in the evenings) is taken to replace the four quarter hour day course equivalent, a special request from the Graduate Engineering office has to be made to the Registrar's Office. In order to have "Substitution" noted by the course on your transcript, you need to file a completed petition with an unofficial transcript and your advisor's or the Department's assigned Graduate Officer's approval with the Graduate Engineering office who will then notify the Registrar.

**Please Note:* There is an eight-quarter-hour limitation on the number of courses you may repeat or substitute. Also, when the notation of "Repeat" or "Substitute" is beside a course on your transcript, the course's quarter hours and grade are no longer calculated into your overall grade point average.

D4- Course Waiver

A course waiver is the replacement of a required course not yet taken in your degree program with an alternative course. To do this, submit a completed petition and unofficial transcript, with the reason for your request, to your advisor or the Department's assigned Graduate Officer for approval. Then file all materials with the Graduate Engineering office for final approval. The petition is retained in your file for graduation review purposes.

D5 - Non-Graduate Engineering Courses

To request that an advanced undergraduate engineering course be applied to your graduate degree program, you will need to submit a completed petition with your advisor or the Department's assigned Graduate Officer's approval, and an unofficial transcript of both the undergraduate course (if already taken) and your graduate courses to the Graduate Engineering office. If approved, the course and its grade will be used toward your graduate degree requirements. There is a four quarter hour limit on the number of undergraduate credit hours which may be used for the graduate degree.

In order to receive credit for graduate courses at Northeastern outside of the School of Engineering, you will need to obtain approval from the Graduate Engineering office.* Submit a completed petition with your advisor's or the Department's assigned Graduate Officer's approval and an unofficial transcript to the Graduate office. Then, if approved, bring your copy of the petition to the graduate school in which the desired course is offered. Usually, you will need to complete a different type of petition for that graduate school at least four weeks prior to the quarter in which the course is being offered. Your copy of the Graduate Engineering petition is verification of approval, and will designate if the non-engineering graduate course is to be applied toward your degree.

Interdisciplinary degree students are not required to follow this procedure when the courses are considered part of the degree program.

**Please Note:* Graduate courses taken in another college at Northeastern, if approved for degree credit, are granted on a course-for-course equivalency and the grade is calculated into your overall grade point average.

D6 - Thesis

Instructions for the preparation of a thesis are available from the Graduate School office, and include proper formatting and procedures for depositing the thesis in Snell Library. The thesis topic is developed with your advisor and the final thesis is approved in accordance with the regulations of the Graduate School of Engineering outlined in the instructions.

D7 - Time Limit Extension

If you come to a point in your graduate work where it becomes evident that you cannot complete your program within the time limit (seven years for Master of Science degree, five years for Engineer degree and PhD candidates), you will need to request approval for a time extension from the Department Graduate Committee. This requires that 1) a completed petition, with your advisor's or the Department's assigned Graduate Officer's approval, 2) an unofficial graduate engineering transcript, and 3) a letter from you stating the reasons for the request, are on file. Your letter, addressed to the Department Graduate Committee, should also state the specific course of action you plan to take in order to complete your degree requirements, and the length of time needed for the extension. If the extension is approved, all materials are placed in your file for graduation clearance purposes.

D8 - Transfer Credit

The Graduate School of Engineering allows up to twelve (12) quarter hours of credit obtained from another institution to be used toward the Master of Science degree. To be eligible for transfer credits, the course(s) must be 1) in the student's field of study, 2) at the graduate level, 3) in a recognized college or university, and 4) carry grades of B or better. The credits cannot have been used toward any other degree and must have been taken within the time limit for your degree completion. Once entered in the program, a student wishing to take a course for transfer credit should petition for approval prior to pursuing the course.

If you are seeking transfer credit approval, you will need to complete a petition and provide an unofficial transcript of your graduate work at Northeastern, a course catalog description and official transcript of the course you wish to transfer. Submit all of these materials to the Department Graduate Committee. If approved, the material is sent to the Graduate School Office. The credits will be applied toward your degree requirements if all transfer credit criteria have been met. However, the grades do not carry over and are not included in the computation of your grade point average required for degree completion. Credits are granted as equivalent to required or elective courses in the Graduate School of Engineering.

UNIVERSITY FACILITIES AND RESOURCES

The Boston Campus

The central Boston campus is built around a quadrangle, one side of which faces Huntington Avenue, a major artery dividing the campus. The buildings surrounding the quadrangle and the innovative design of new buildings such as the library that have been added in recent years has maintained an architectural theme that is both attractive and functional.

The campus itself has been planned to provide easy access to classrooms, laboratories, and administrative offices through a series of connected walkways and a network of underground corridors providing routes that are especially convenient during periods of inclement weather. As the University continues to expand, parking and recreational areas are integrated into the campus along with new academic facilities.

Suburban Facilities

Northeastern University's five suburban campuses provide administrative and classroom facilities for the University's graduate, adult and continuing education programs as well as the environment necessary for specific programs of study that could not be accommodated in an urban area.

The Warren Center provides a practical laboratory in outdoor education and conservation, and in camping administration, programming, and counseling. It also offers a summer campsite for various community and University groups and activities and is available as a conference and workshop site.

The Marine Science and Maritime Studies Center is located in Nahant, on Massachusetts Bay, 20 miles northeast of Boston and serves as a site for national and international as well as University research.

Henderson House is Northeastern University's conference center. Located 12 miles from Boston in suburban Weston, Henderson House hosts a variety of round-the-clock activities including residential seminars, workshops, short courses, and weekend meetings.

The Suburban Campus of Northeastern University is located in Burlington near the junction of Routes 128 and 3. Graduate courses in engineering, business administration, and education as well as undergraduate courses for part-time students are offered here. The Burlington Campus also offers special programs for adults and noncredit continuing education courses.

The Suburban Campus is situated close at hand to another Northeastern University facility, the Botanical Research Station in Woburn, which contains a small arboretum and a spacious greenhouse used for propagation and research.

One of the most recent campus acquisitions is the 20-acre Dedham Campus, just north of Route 128. This recently renovated facility provides space for the College of Business Administration's new High Technology MBA program and offices for the Center for Continuing Education, and houses the University's new outdoor track and field facility.

The Henderson Boathouse - Brighton, Massachusetts

The Henderson boathouse is located on the banks of the scenic Charles River in Brighton, Massachusetts. The five-bay, two-story facility houses both the men's and women's crew teams.

University Libraries

The University Libraries include units that support the academic programs at the Boston, Burlington, and Dedham Campuses and at the Marine Science and Maritime Studies Center in Nahant. The Snell Library, the new main library for the Boston campus, opened in 1990, and it is, at 240,000 square feet, the largest academic library building in Boston. A five-level structure with 2,700 seats and shelving for more than 1.25 million volumes, it triples previous library capacities for both seating and on-site collection accessibility. The facility incorporates the latest online, telecommunication, and media technologies.

Snell Library is introducing an online system that automates many of its services and operations. An online catalog of most of the Library's holdings is linked with online circulation and acquisitions systems so that the display shows whether a particular book is currently charged out from the library or is on order. The online catalog is accessible through terminals in the libraries as well as from elsewhere both on and off campus through the University's academic computer network. There are three microcomputer laboratories in the main library. In addition, 500 study carrels are wired so that students own portable computers may access the academic computer network from the library.

Holdings of the University Libraries include more than 620,000 volumes, 1,450,000 microforms, 250,000 government documents, and current subscriptions to more than 7,000 serials. A large reference collection is in the main library. The collections also include other types of materials, such as technical reports, musical scores, maps, and CD-ROM optical disc databases. The library's Media Center has an extensive colleciton of computer software, language tapes, music recordings, and other audio and video materials.

Librarians provide assistance and instruction on bibliographic research strategies for identifying, locating, and using information resources to meet the general and specialized needs of graduate students.

Boston Library Consortium

Northeastern University is a member of the Boston Library Consortium, a cooperative arrangement among the following institutions: Boston College, Boston Public Library, Boston University, Brandeis University, MIT, the State Library of Massachusetts, Tufts University, the University of Massachusetts (Amherst, Boston and Worcester campuses),

and Wellesley College. The University's borrowing privileges in the Boston Library Consortium generally allows for on-site use by, but does not grant borrowing privileges to, students at Northeastern. Graduate students and faculty may apply at the Reference Desk for a Consortium card that will allow borrowing privileges at consortium libraries.

Computing Resource Center

The Computing Resource Center supports research activities of faculty, research personnel, and graduate students, as well as teaching and learning activities at both the graduate and undergraduate levels. The computational capability of this facility centers on the Academic Computing Network (ACN), an Ethernet-based wide-area network connecting labs, offices, and the suburban campuses to university computing facilities and to Internet and BITNET, two international computing networks. Time-sharing computing is provided through the VAXcluster, which includes a VAX 8650 and a VAX 11/785, the latter being operated by the College of Engineering. Remote access is possible through the use of dial-up facilities is promoted by availability of programming assistance at all three campuses.

Electronic spreadsheet and word-processing packages are available, as well as numerous software libraries for numerical, statistical, and financial applications. The primary languages supported for those who do their own programming are FORTRAN, COBOL, BASIC, Pascal, C, and Assembly Language.

Graduate Student Housing

Housing in a University apartment facility is available on a first-come, first-served basis. These fully furnished apartment facilities offer units designed for two, three, or four students.

Department of Career Services

The Department of Career Development and Placement offers a wide range of counseling and placement assistance to all undergraduates, graduate students and alumni of Northeastern University seeking employment, to undergraduates seeking admission to graduate or professional school; and to students interested in participating in nonpaid, part-time internships in private or public nonprofit agencies for which they may receive academic credit.

Through this department, representatives of hundreds of employers are scheduled to visit the campus each year to interview seniors and graduate students for full-time employment after graduation. A job bank of currently available positions is maintained for alumni who are seeking new opportunities for which they may be qualified. Credential service is provided for students and alumni seeking positions in the field of education and for applicants to graduate and professional schools. Regularly scheduled seminars are conducted for seniors, graduate students and alumni on career development, job-finding techniques, resume preparation and effective interviewing. Individual career counseling is available for seniors, graduating seniors and alumni of all University programs. The Career Resource Center offers print and computerized resources on occupational information and graduate schools.

Sport, Dance and Exercise Facilities

Through its Cabot Center for Physical Education, Dockser Hall and Barletta Natatorium, Northeastern University offers a wide variety of specialized facilities, including basketball courts, dance studio, indoor athletic field and running track, gymnastics room, combatives room, weight-training rooms, swimming pool, crew practice tank, racquetball courts, and motor performance and exercise physiology laboratories. The Matthews Arena, with seating for more than 5,000 fans, provides home ice to the University's varsity and subvarsity hockey teams and, when the portable playing floor is down on the ice, home court to the University's basketball teams.

For organized athletics requiring facilities not available on the main campus, Northeastern maintains several off-campus locations, including the Henderson Boat House, in Brighton. The Edward S. Parsons Field, on Kent Street in Brookline, is the playing ground for the football, baseball, women's lacrosse and women's field hockey teams, tennis, and some intramurals.

The Bernard and Jolane Solomon Track

The Bernard M. and Jolane Solomon Track, a recently completed outdoor track and field facility in Dedham, has an eight lane, Action Track 200 running surface, and an expansive area for concurrent jumping and field events. This new facility is ready to host dual and championship meet competition, and is a permanent site for Northeastern University track athletics.

Ell Student Center

The Carl S. Ell Student Center provides facilities for student recreation and extracurricular activities. The Alumni Auditorium, with a seating capacity of 1,300, is part of the Center. Also included are special drama facilities, a ballroom, main lounge, fine arts exhibition area, student offices, conference rooms, cafeteria with seating for more than 1,000 and the bookstore.

Lane Health Center

A comprehensive program of medical care is provided to all full-time graduate and undergraduate students. The University maintains a Health Services Clinic, which is open for emergencies at all times and is equipped to deal promptly with any medical condition that may arise. All entering full-time students must submit a pre-entrance physical examination form provided by the Lane Health Center prior to registration. Failure to fulfill this requirement can delay registration and result in a penalty fee and additional fee for a physical examination.

Counseling and Testing Center

Counseling and testing to aid a student with career, educational, or personal concerns are available days 8:30 AM to 4:30 PM. Information and appointments may be obtained by calling (617) 373-2142 or by visiting the Counseling and Testing Center.

Disability Resource Center

Any student who has a disability-related special need, no matter how small or individual, can receive ready support services from the Disability Resource Center (DRC). Frequently, students are uncertain about how they may be aided by this office, and in these situations a discussion of possible alternatives can be quite helpful. DRC provides a wide range of support services to eliminate the competitive disadvantages that a disability may create. Services are individually tailored to meet the needs of each student.

The types of assistance available from the Disability Resource Center include orientation, registration and preregistration, information clearinghouse, counseling, help in locating housing, services for the visually-impaired, the hearing-impaired, the wheelchair user/ mobility-impaired student, and students with learning disabilities.

The Disability Resource Center is also the gathering place for the Northeastern University Deaf Club, a supportive group for students with learning disabilities and the Disabled Student Organization of Northeastern University, which works cooperatively with DRC to plan programs and improve accessibility of services for handicapped persons at Northeastern.

Network Northeastern

Network Northeastern represents the University's entry into the age of education by telecommunications. The Network utilizes the microwave-based Instructional Television Fixed Service (ITFS) system whereby educational services are broadcast directly to company sites and other remote locations within a 40-mile radius of Northeastern's Boston campus. With this service, live classroom instruction is telecast in color to remote sites where it is viewed in reception rooms equipped with TV monitors and a telephone-based talkback system. During presentation, off-campus students are able to participate as fully in the instruction as can students sitting in the originating classroom on campus. A courier service is provided to collect and deliver homework assignments, and to serve as the off-campus student's link to the bookstore, registrar, and other campus services.
Network Northeastern currently offers courses in graduate engineering, graduate computer science, undergraduate engineering technology, state-of-the-art professional development courses, and non-credit nursing courses. This instruction is telecast daily between 8:00 a.m. and 10:00 p.m. on four channels to off-campus students at thirty-five company sites and two suburban campuses.

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The Council determines broad policies and regulations governing the conduct of graduate work. All new graduate programs must be approved by the Council.

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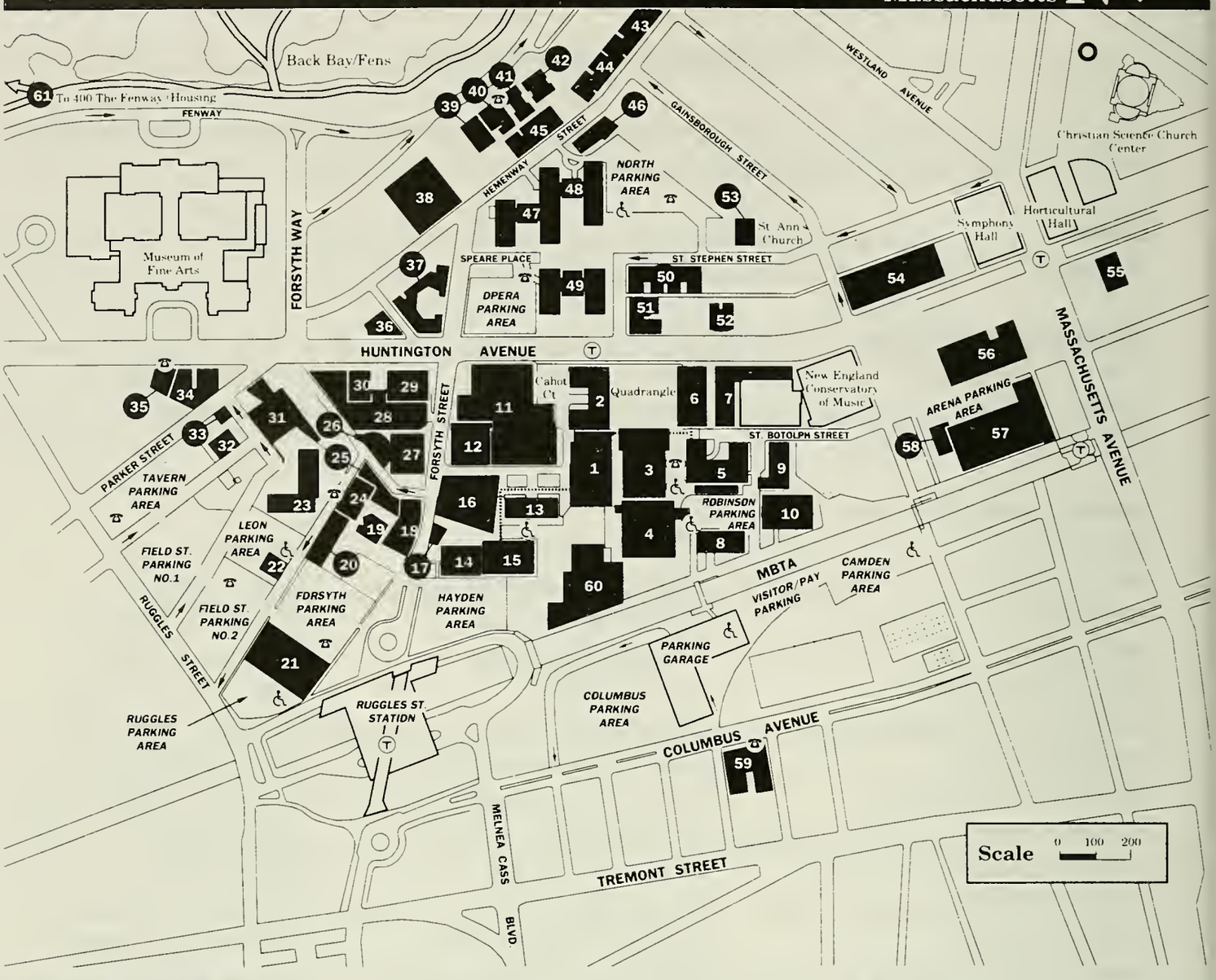


Academic and Service Buildings

- 22 Africon-American Institute (AF)
- 12 Barletta Natatorium (BN)
- 19 Boiler Plant
- 11 Cabot Physical Education Building (CB) **TTY**: Rm 110
- 39 Cahners Hall (CA) **TTY**: Rm 151
- 28 Cargill Hall (CG)
- 13 Churchill Hall (CH)
- 59 Columbus Place (716 Columbus Avenue) (CP)
- 56 Cotting School (CT)
- 9 Cullinane Hall (CN)
- 40 Cushing Hall (CU)
- 14 Dana Research Center (DA)
- 27 Dockser Hall (DK) **TTY**: Rm 107
- 6 Dodge Building (DB)
- 3 Ell Student Building (Auditorium) (EL) **TTY**: Rms 04, 104
- 4 Ell Student Center (Student Lounge) (EC) **TTY**: Rm 255
- 16 Forsyth Building (FR) **TTY**: Rms 100, 135
- 17 Forsyth Building Annex (FA)
- 38 Forsyth Dental Building (FE)
- 1 Hayden Hall (HA) **TTY**: Rms 120, 202
- 33 Hillel-Froger (HF)
- 24 Holmes Hall (HO) **TTY**: Rm 276
- 55 236 Huntington Avenue (HU)
- 7 316 Huntington Avenue (Northeastern at the YMCA) (BY)
- 54 Huntington Plaza (271 Huntington Avenue) (HN)
- 10 Hurtig Hall (HT)
- 26 Koriotis Hall (KA)
- 41 Kerr Hall (Faculty Center) (KH)
- 29 Knowles Center (KN)
- 25 Lake Hall (LA) **TTY**: Rm 203
- 57 Matthews Arena (MA)
- 58 Matthews Arena Annex (MX)
- 20 Meserve Hall (ME) **TTY**: Rm 305
- 5 Mugar Life Science Building (Peabody Health Professions Center) (MU)
- 18 Nightingale Hall (NI) **TTY**: Rm 125
- 31 Parker Building (PA)
- 2 Richards Hall (RI) **TTY**: Rms 150, 254
- 8 Robinson Hall (RB)
- 21 Ryder Hall (RY) **TTY**: Rms 170, 180, 251, 270
- 15 Snell Engineering Center (SN) **TTY**: Rm 120
- 60 Snell Library (SL) **TTY**: Reference Desk
- 50 122 St. Stephen Street (SS)
- 30 Stearns Center (ST) **TTY**: Rm 302
- 32 26 Tavern Road (TA)

Key

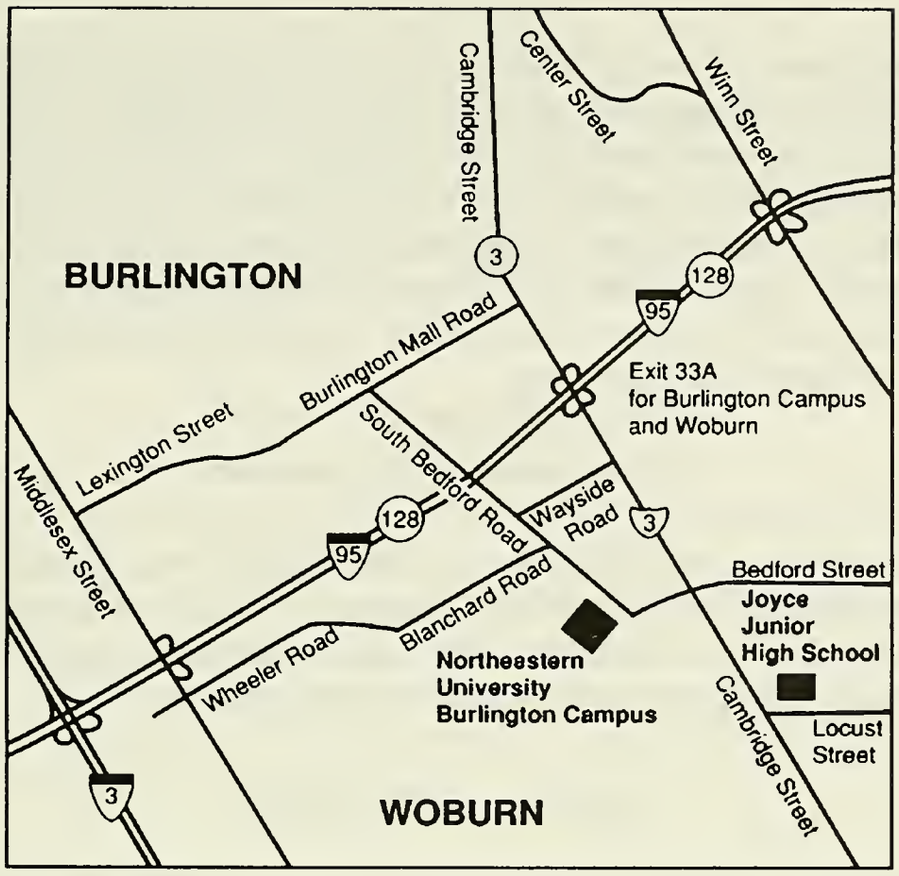
- Academic, residential, and service buildings
- Handicap parking
- Parking areas
- Street direction
- Underground tunnel
- Emergency telephone
- TTY locations (**TTY**: Rm 000)

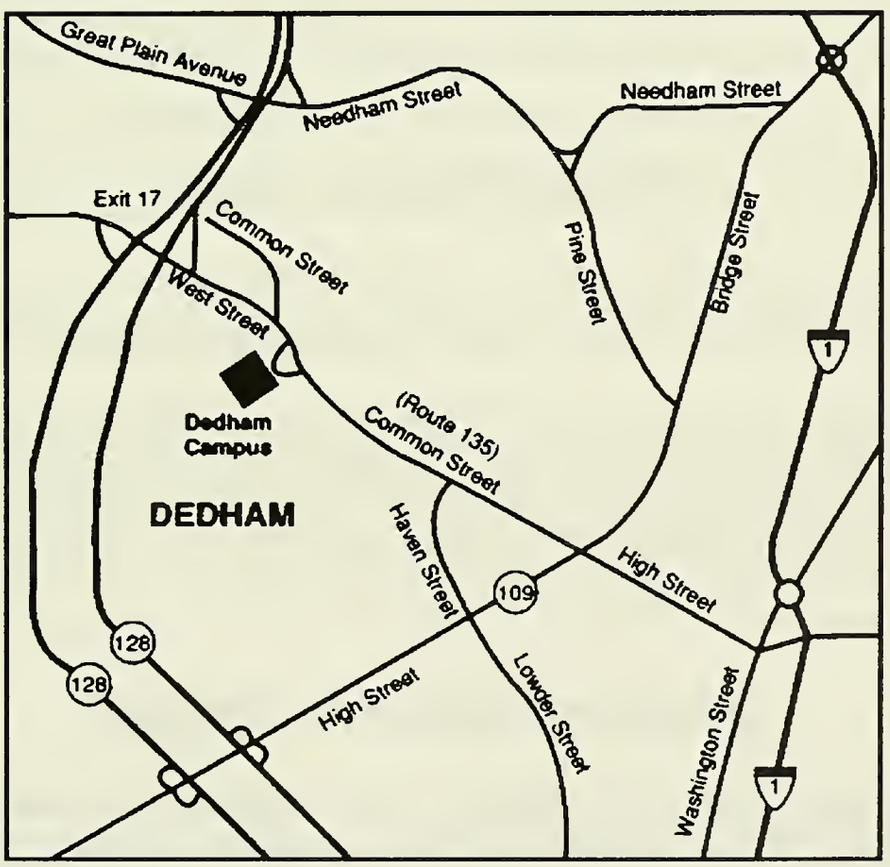
See alphabetic list of buildings for **TTY** locations.

Maps are provided by the Information Center, 115 Richards Hall, extension 2736 (TTY extension 3768). Some buildings on this map are used but not owned by Northeastern University. 6/91

Residence Buildings

- 34 Burstein Hall
- 43 Kennedy Hall
- 46 142–148 Hemenway Street
- 45 153/157–163 Hemenway Street
- 7 316 Huntington Avenue (Northeastern at the YMCA)
- 52 319 Huntington Avenue
- 51 337 Huntington Avenue
- 36 407 Huntington Avenue
- 41 Kerr Hall
- 53 Light Hall
- 42 Melvin Hall
- 35 Rubenstein Hall
- 44 Smith Hall
- 49 Speare Hall
- 48 Stetson East **TTY** (public)
- 47 Stetson West
- 50 106/110/116/122 St. Stephen Street
- 23 Willis Hall
- 37 White Hall
- 61 400 The Fenway


BURLINGTON
Cambridge Street
Center Street
Winn Street
3
128
95
Burlington Mall Road
Exit 33A
for Burlington Campus
and Woburn
Lexington Street
South Bedford Road
Wayside
Road
3
Middlesex Street
128
95
Bedford Street
Joyce
Junior
High School
Blanchard Road
Northeastern
University
Burlington Campus
Wheeler Road
Cambridge Street
Locust
Street
3
WOBURN


Great Plain Avenue
Needham Street
Needham Street
Exit 17
Common Street
Pine Street
Bridge Street
West Street
1
Dedham
Campus
(Route 135)
Common Street
DEDHAM
Haven Street
High Street
109
128
128
High Street
Lowder Street
Washington Street
1

The Northeastern University Graduate School of Engineering Student Guide and Catalogue contains the University's primary statements about these academic programs and degree requirements, as authorized by the president or Board of Trustees. For information about other academic policies and procedures; student responsibilities, academic and cocurricular life; faculty rights and responsibilities; or general personnel policies, benefits, and services, please refer to the *Academic Operations Manual, Undergraduate and Graduate Student Handbook, Cooperative Education Handbook, Benefits and Services Handbook*, and related procedural guides as appropriate.

Accreditation Statement

Northeastern University is accredited by the New England Association of Schools and Colleges, Inc., which accredits schools and colleges in the six New England states. Accreditation by the Association indicates that the institution has been carefully evaluated and found to meet standards agreed upon by qualified educators.

Delivery of Services

Northeastern University assumes no liability for delay or failure to provide educational or other services or facilities due to causes beyond its reasonable control. Causes include, without limitation, power failure, fire, strikes by University employees or others, damage by natural elements, and acts of public authorities. The University will, however, exert reasonable efforts, when it judges them to be appropriate, to provide comparable service, facilities, or performance; but its inability or failure to do so shall not subject the University to liability.

Disability Resource Center

The Disability Resource Center provides a variety of disability-related services and accommodations to Northeastern University's students and employees with disabilities.

Northeastern University's compliance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 are coordinated by the Dean and Director of the Disability Resource Center. Persons requiring information regarding the Disability Resource Center should contact Dean G. Ruth Bork at (617) 373-2675 (voice) or (617) 373-2730 (TTY).

Emergency Closing of the University

Northeastern University has made arrangements to notify students, faculty, and staff by radio and television when it becomes necessary to cancel classes because of extremely inclement weather. AM radio stations WBZ (1030), WEEI (590), WHDH (850), WRKO (680), and FM stations WBCN (104.1) and WBMX (98.5) are the radio stations authorized to announce the University's decision to close. Television station WCVB-TV5 will also report cancellations. Since instructional television courses originate from live or broadcast

facilities at the University, neither the classes nor the courier service operate when the University is closed. Please listen to the radio or television to determine whether the University will be closed. If a storm occurs at night, the announcement of University closing is given to the radio stations at approximately 6 AM. Classes are generally canceled for that entire day and evening at all campus locations unless stated otherwise. When a storm begins late in the day, cancellations of evening classes may be announced. This announcement is usually made between 2-3 PM.

Equal Opportunity Policy

Northeastern University does not discriminate on the basis of race, color, religion, sex, sexual orientation, age, national origin, disability, or veteran status in admission to, access to, treatment in, or employment in its programs and activities. In addition, Northeastern University will not condone any form of sexual harassment. Handbooks containing the University's nondiscrimination policies and its grievance procedures are available in the Office of Affirmative Action, 175 Richards Hall. Inquiries regarding the University's nondiscrimination policies may be directed to:

Ellen S. Jackson, Dean/Director
Office of Affirmative Action
175 Richards Hall
Northeastern University
Boston, Massachusetts 02115
(617) 373-2133

Inquiries concerning the application of nondiscrimination policies may also be referred to the Regional Director, Office for Civil Rights, United States Department of Education, J.W. McCormack Building, Post Office Court House, Room 222, Boston, Massachusetts 02109-4557.

Family Educational Rights and Privacy Act

In accordance with the Family Educational Rights and Privacy Act of 1974, Northeastern University permits its students to inspect their records wherever appropriate and to challenge specific parts of them when they feel it is necessary to do so. Specific details of the law as it applies to the University are printed in the *Undergraduate and Graduate Student Handbook* and are distributed annually at registration of the University's colleges and graduate schools.

Insufficient Enrollment Disclaimer

Northeastern University reserves the right to cancel any course if minimum enrollments, appropriate faculty, or academic facilities are unavailable to meet standards.

Tuition and Fee Policy

Tuition rates, all fees, rules and regulations, courses and course content are subject to revision by the President and the Board of Trustees at any time.

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Graduate School of Engineering
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